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DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

REPORT OF THE FOREST PRODUCTS RESEARCH BOARD

FOR THE YEAR 1935

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DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

REPORT OF THE FOREST PRODUCTS RESEARCH BOARD

With the Report of the Director of Forest Products Research FOR THE YEAR 1935

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REPORT OF THE FOREST PRODUCTS RESEARCH BOARD FOR THE YEAR 1935

To the Lords of the Committee of the Privy Council for Scientific and Industrial Research

MAY IT PLEASE YOUR LORDSHIPS,

WE, the Forest Products Research Board, beg leave to present our Report for the Year 1935.

The Board met only once during the year, on Wednesday, 13th March, at the Offices of the Department of Scientific and Industrial Research, 16 Old Queen Street, Westminster, S.W.1. For various reasons the second meeting, which ordinarily would have been held in the autumn, was postponed until after the close of the year under report. At the meeting on 13th March, the Board learnt with satisfaction that a new organisation, to be called the Colonial Forest Resources Development Department, was to be brought into being by the Colonial Office for marketing work in connection with Colonial timbers. The Board also noted with approval that arrangements had been made for the Forest Products Research Laboratory to be represented at the Fourth British Empire Forestry Conference in South Africa and at the Sixth International Botanical Congress at Amsterdam later in the year.

A memorandum submitted by the Director of Forest Products Research, dealing with the need for further research in connection with the damage to timber structures by marine borers, was considered and discussed at considerable length, following which the Board asked the Director to submit a scheme at the next meeting. Statements concerning the position reached in the development of the facilities for box-testing, the possibility of establishing a substation of the Forest Products Research Laboratory in Scotland, and enlargement of the scope of the investigation of problems connected with woodworking were also considered.

The Board is pleased to note that there is direct evidence of appreciation by industries concerned in the manufacture of both wooden and fibre-board boxes, as well as by users of such boxes, of the facilities now available in the new box-testing laboratory.

Satisfactory progress has been made during the year in the work under the revised programme of research. The Board notes with satisfaction the advance which has been made in the investigation of those physical properties of timber which have a direct influence on its behaviour during seasoning and when in

use. The results promise ultimately to be of material importance to architects and those engaged in any form of industry in which timber is used.

A new series of publications, called the Forest Products Research Records, in which the results of the various investigations are presented in a form as free as possible from technical detail, has been introduced. The Board considered that the series had been well conceived, and was likely to bring to the notice of users of timber much valuable information which had hitherto failed to reach them.

J. C. IRVINE
Chairman

June 1936

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH,
16 Old Queen Street,
Westminster, S.W.1

REPORT OF THE DIRECTOR OF FOREST PRODUCTS RESEARCH FOR THE YEAR 1935

I. GENERAL

Introduction

This report contains a summarised account of the work which has been in progress during 1935 under the various projects included in the programme of research of the Forest Products Research Laboratory, and of the activities of the staff of the Laboratory designed to promote contacts with industry. Full accounts of completed investigations are published separately and details of these publications are to be found in Appendix III of this report.

Satisfactory progress has been made in all branches of the work of the Laboratory during 1935. Perhaps the most reliable index of appreciation of the value of the work is the number of applications for assistance and information which are received at the Laboratory, totalling about 2,200 for the year under report, and if these can be accepted as a standard it is clear that the facilities offered by the Laboratory are now valued more highly than at any previous time in its history. Favourable comments have been received concerning the efforts to make more widely available the results of work carried out at the Laboratory in a form which can be understood by those who have not undergone special scientific or technical training, and the reception accorded to the new series of publications issued to further this policy has been satisfactory. It is hoped that the demand for these publications will increase as they become better known. It is certain that the desire for specific knowledge of the properties of commercial timbers has grown considerably during the past few years. Members of the timber trade and timber using industries are awakening to the need for more research directed to the solution of some at least of the many problems connected with wood and for definite information which will enable architects, builders, engineers and others to use timber with confidence. Much remains to be done to spread knowledge of the nature of the work of the Laboratory and of the help which it can give to the trade.

The Summer School and other Educational Activities

For some years past representatives of firms engaged in the manufacture of timber or timber goods, and instructors in building science or woodworking at various technical schools, have sought permission to visit the Laboratory for periods of varying length to obtain instruction and information which cannot be provided in purely educational institutions. To minimise the interference with the routine work of the Laboratory involved in such visits and

the better to gauge the need for facilities of this kind, it was decided to hold a short course lasting for one week in September, 1935, as an experiment, the number of accepted applications being limited. Five places were reserved for technical instructors at the request of the Board of Education and the remaining places were allotted to principals and nominees of various firms of timber merchants, manufacturers and others, to the total number of thirty-two. Several university graduates and one undergraduate were among those selected. It was clear from the reception of the announcement that the experiment had a strong appeal, and the letters which reached the Laboratory or appeared in technical and trade journals after the course had been completed showed very definitely that there is a keen appreciation of the facilities offered by the Summer School and an urgent demand for the repetition of the experiment. A number of applications for permission to attend a similar course in 1936 have been received.

There have been numerous requests for lectures in various parts of the country. The interest to architects and surveyors of the Laboratory's work upon damage caused to timber by fungal diseases and insect pests was shown by the discussion which followed a lecture[1] given at the request of the Chartered Surveyors' Institution in March. The increase in the number of requests for articles for publication in technical and trade journals is further evidence of a growing realisation of the need for research work and an enhanced desire for the more exact knowledge which is accumulated as its result.

[1] Cartwright, K. St. G., and Fisher, R. C. Decay of Timber in Houses. *Trans. chart. Surv. Instn.*, 1935, **67**, 184–232.

The Fourth Empire Forestry Conference

The Laboratory was represented at the Fourth Empire Forestry Conference, which was held in South Africa in the autumn of 1935, by the officer in charge of the Timber Mechanics Section. On behalf of the Laboratory he contributed three papers on—

(*a*) *Forest Products Research, Objectives and Methods*; (*b*) *The Utilisation of Small Material*; and (*c*) *Statistical Methods in Timber Research.*

At the conclusion of the Conference the officer revisited the Forest Products Institute at Pretoria and paid some special visits to important timber-using centres in the Union.

Collection of Wood Specimens

The Laboratory's working collection of timbers has been enlarged during the year by a record number of additions. New acquisitions include collections from the Federated Malay States, Sarawak, Sumatra, Burma, Uganda, Gold Coast Colony, Trinidad and Hong Kong, and grateful acknowledgment is made to those Forest

Departments which have been responsible for the onerous task of collecting and transmitting the material. Useful samples of commercial timbers have also been acquired through the kind offices of various importers and timber merchants. Commercial samples are often of special interest as representing the grade and quality of timber in common use: in fact, the practical value of the collection depends in no small measure on its including a proportion of such material to supplement the main series of botanically authentic specimens. On the 31st December, 1935, the total number of catalogued specimens amounted to 9,587, representing 3,300 separate species, 451 of which were received during the year.

The Classification of Commercial Timbers

Specimens of timbers from all parts of the world, numbering well over a thousand in an average year, are examined and classified before being incorporated in the Laboratory's wood collection. Special attention is naturally devoted to timbers of economic importance, which are critically examined for their resemblances and differences, their range of variation and their structural peculiarities. Their geographical distribution is investigated at the same time. The ultimate object of these studies is to determine the normal range of the structure and general properties of each species. Thus, every new specimen which is found to differ materially from those already in the collection may alter the conception already formed of the species concerned and incidentally may widen existing knowledge of its technical properties and potential uses. The results of this work, which from its very nature is never completed, are embodied in the Laboratory's permanent records, which are continually being drawn upon for reference. It may be mentioned that these studies are not rigidly confined to the examination of small hand specimens, for in order to be conversant with the kinds and qualities of timber in common use it is necessary from time to time to inspect bulk consignments of home-grown and imported timbers. During the year under review particular attention has been given to several important groups of commercial timbers, including the family Dipterocarpaceæ (seraya, meranti, lauan, gurjun, etc.), the Meliaceæ or mahogany family, and other timbers in the mahogany class, and commercial softwoods.

International Co-operation in Wood Structure Research

The Laboratory has collaborated in a number of projects designed to achieve a greater measure of co-operation between wood anatomists in different parts of the world. Through the medium of the International Association of Wood Anatomists, notable advances have been made in the standardisation of terminology and technical methods. The closer relations which have been established with wood anatomists in other countries are of direct benefit to the Laboratory, which is naturally interested in the scientific investigation of timbers from all parts of the world

The Laboratory was represented at the Sixth International Botanical Congress in Amsterdam, where one session was devoted to papers dealing with wood anatomy[1], and several matters which have been the subject of protracted correspondence, with a view to international standardisation, were discussed to the advantage of all concerned.

[1] RENDLE, B. J. Variation in Wood Anatomy. Paper presented to the Sixth International Botanical Congress, Amsterdam, September, 1935.

Collection of Fungi

The herbarium collection of sporophores and of typical rots has been completely rearranged in a form more readily available for reference. Numerous additions have been made to the collection and a very useful gift of *exsiccata* from Dr. Pilat of Prague, resulting from a discussion with him at the Sixth International Botanical Conference held in Amsterdam which was attended by the Officer in charge, Mycology Section, must be recorded. The number of fungi maintained in culture has also increased, and the policy of extending the collection of cultures is fully justified by the many requests for standard cultures of wood-destroying fungi.

The construction of a constant temperature room built to hold about 1,500 flasks has enabled a much larger number of tests to progress simultaneously than was previously possible.

Exhibitions

The Laboratory co-operated with the Building Research Station in preparing exhibits for the Building Trades Exhibitions at Bradford and Manchester. The enquiries dealt with by officers in attendance and in subsequent correspondence bear witness to the interest with which architects and others regard timber research and its application to the building trade.

A special exhibit, illustrating the relation between the rate of development of the Death-watch beetle and extent of decay in timber, was prepared for the Royal Society Conversazione in May. The same exhibit was displayed by request at a Conversazione at the Institution of Civil Engineers in June. An exhibit on the Death-watch beetle was sent to the Incorporated Church Building Society for display at the Church Congress in Bournemouth in October.

The Laboratory also supplied certain items for the Forestry Commission exhibits at the Royal Agricultural Show, Newcastle, and the Royal English Forestry Society exhibit at the Bath and West Show, Taunton.

Staff

The number of persons of all ranks employed at the Laboratory on 31st December, 1935, was 149. Details of the Scientific and Technical Staffs are to be found in Appendix I.

II. THE PROGRAMME OF RESEARCH

The Relation between the Structure and the Technical Properties of Wood

In seeking to explain the properties of timber on structural grounds, it has been shown that almost every technical property of timber depends partly on its gross anatomy and partly on other factors, which are variously ascribed to the presence of infiltrated substances, the physico-chemical composition of the wood, and the sub-microscopic structure of the cell wall. The bulk of the solid material in a piece of timber is contained in the fibres, and there is reason to believe that the structure and composition of the fibre walls constitute an important factor in determining the technical properties of the wood. The walls of wood fibres are not homogeneous, but consist of two or more layers which are visually distinct under the microscope and are believed to differ in certain important respects which affect the properties of the wood. The composition of the fibre walls has, therefore, been the object of special attention in investigating the general relations between the structure and properties of wood. As instances of the wide influence of this feature may be mentioned the phenomenon of "honeycombing" in chestnut, abnormal shrinkage in beech, and the woolly machine finish on certain grades of mahogany, all of which defects may be caused by gelatinous fibre walls. Abnormal warping of lead pencils has also been traced to a structural feature of the wood tracheids, presumably owing to stresses affecting the standing tree.

The Relation between the Structure of Wood and its Mechanical Strength

(*a*) *Ash.*—In continuing the study of wood structure in relation to mechanical strength, investigations have been directed towards the unexplained variation which is found in ash timber from different localities, and also from different trees grown in the same locality. The fact that specimens of the same specific gravity and closely similar anatomical structure sometimes differ by more than 30 per cent. in maximum crushing strength suggested that the physical and chemical nature of the wood substance might be of considerable importance in affecting the strength of the timber. Several methods have been tried to distinguish the relatively strong and weak types of timber, the specimens being matched as closely as possible in respect of specific gravity and anatomical structure. It has now been found that a solution of phloroglucin in hydrochloric acid has the effect of differentiating between such strong and weak types of ash, and by means of the same reagent it has also been shown that the physical or chemical nature of the secondary walls of the wood fibres is largely responsible for the strength of the wood under compression parallel to the grain. With regard to the nature of the chemical reactions involved, it can only be said that of the

various so-called standard lignin reagents used in histological work, phloroglucin-hydrochloric acid is apparently the only one capable of differentiating between strong and abnormally weak types of ash.[1]

As foreshadowed in the report for 1934, a study of the toughness of ash has been started, and four consignments of trees from different parts of the country have been investigated. Previous tests have shown that while the butt logs of a tree yield the toughest wood, the upper logs are strongest in compression parallel to the grain, so that there is reason to expect these two types of strength to bear different relations to the structural features of the wood. Recent investigations indicate that toughness (unlike strength in compression) depends more on the nature of the middle lamellæ and the primary walls (Plate I) than on the secondary walls of the fibres. These conclusions have been published.[2]

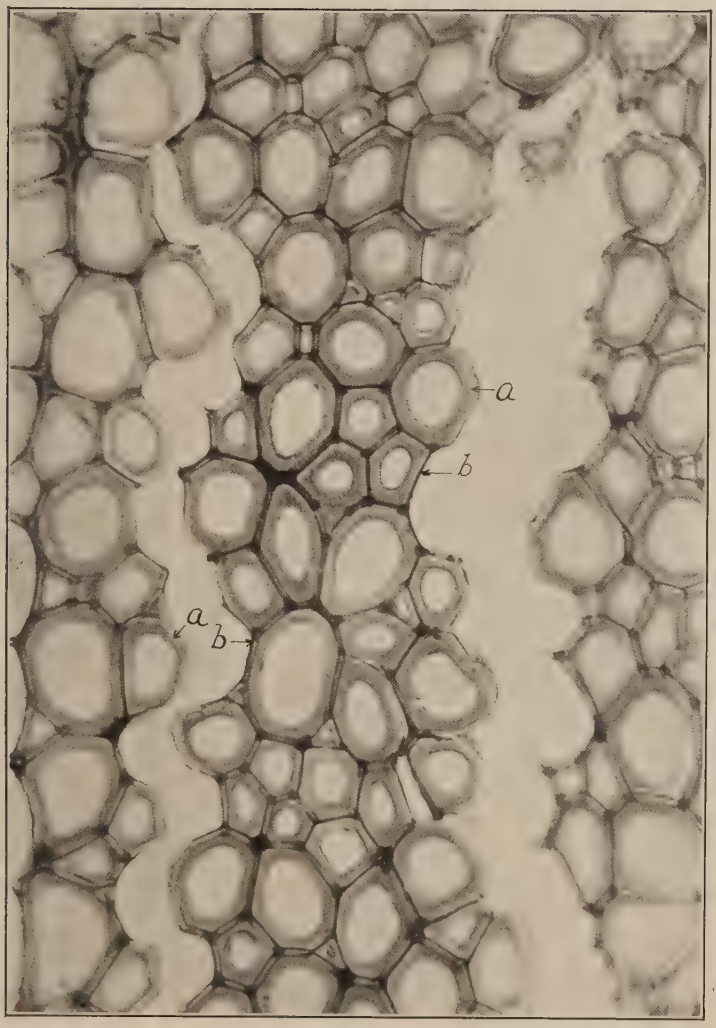
The material from the four localities sampled showed wide differences in toughness both in the trees from any one locality and in the trees from the different localities. A detailed statistical analysis of these differences was made, using for comparison discs from the same height in the trees, and within the limits of the investigation it was found that the variance in strength and toughness of the mean values of trees within individual sites was greater than that of the mean values of individual consignments. The densest and toughest material was found near the centre of the tree. Passing outwards there was at first a gradual decrease in both specific gravity and toughness, but at some point, depending apparently on the external growth conditions and differing from tree to tree, no further decrease was noted, the two properties appearing to fluctuate about some mean value or even to increase slightly with increasing distance outwards.

(*b*) *Sitka Spruce.*—The investigation of home-grown Sitka spruce has led to a re-examination of certain previously established relations to determine the extent to which these are independent of each other. The application of new statistical methods has shown that both specific gravity and ring width exert independent influence on maximum crushing strength, but that the proportion of summerwood has little intrinsic effect, being itself a function of the ring width. The presence of compression wood has been shown to produce a higher compressive strength than can be reasonably accounted for by the higher specific gravity of this dense tissue. It remains to be shown how far the results obtained are applicable to other material of better quality than that previously available, and also to determine the causes of strength variation beyond that explained by the factors already referred to.

[1] Clarke, S. H. Application of Microchemical Tests in Assessing the Quality of Ash Timber. *Nature*, 1935, **135**, 910.

[2] Clarke, S. H. Recent Work on the Relation of Anatomical Structure and Mechanical Strength in English Ash. *Forestry*, 1935, **9**, 132–138.

PLATE I



Photomicrograph (*x* 750) *of Transverse Section through Zone of Failure in Toughness Test-piece of* Fraxinus excelsior.

Note that failure takes place by a separation of the fibres in the region of the middle lamella (*b*). The secondary walls (*a*) are not themselves ruptured.

x 14775

Statistical Methods

It is often desirable when making measurements on wood to make corrections for several natural features which are simultaneously varying over the field of the experiment. For instance, comparisons of treated and untreated wood, to be fair, should be made with pieces of the same density and rate of growth, but as such pieces are not usually available, it is practicable to make a correction for such differences as exist in these features. Where graphical means fail because of the simultaneous variation of more than two features, statistical methods can be used and have the additional advantage that they provide a test by means of which the additional precision provided by a proposed correction may be judged.

Examples of data which have been treated in this way are flame penetration times in which comparisons between species have been less precise than they need be because of the unavoidable variation from piece to piece of such features as density and inclination of growth rings.

Examination of data on the chemical constitution of ash has shown the considerable influence of the more prominent constituents on the crushing strength. A similar examination of strength and structural data of Sitka spruce has shown that in the case of this species the strength variations between trees of the same consignment are to be explained almost entirely by variation in structural features.

An example of the use of statistical methods in the control of experiment is provided by the egg-box testing started this year. Replicated tests will, naturally, vary in their results, but the nature of the variation is capable of prediction and significant departure from the expected form will indicate failure to reproduce sufficiently exactly the conditions of test.

Examples of the usefulness of statistical methods in experimental work in this Laboratory have been given in a paper to the Empire Forestry Conference.[1]

[1] E. D. van Rest. Statistical Methods in Timber Research. British Empire Forestry Conference, South Africa, 1935.

Measurement of Cell Space Ratio

The determination of the cell space ratio by measuring photoelectrically the amount of light transmitted by a stained microsection has been further perfected. The use of a Westinghouse "green sensitive" photocell, mentioned in the last report, proved satisfactory for sections of 1 sq. cm. in area or over, and had the advantage of being simple in operation, but a great improvement was made by using a Lindemann electrometer with which to measure the photoelectric current from a vacuum type of photocell. With this electrometer the sensitivity of the instrument is increased at

least twenty times over the valve amplification method formerly used, and it is now possible to measure to about 2 per cent. the cell space ratio of areas within a single annual ring and thus, for example, to differentiate between spring and summer wood.

Optical Measurement of Smoothness

In the report for 1933 a method was described of judging the "finish" of planed wood surfaces by measuring photoelectrically the degree of scattering to which a parallel beam of light is subjected when illuminating the surface. With the improvement of the photoelectric photometer mentioned above, it was decided to continue this work which had lapsed during 1934. The apparatus has recently been rebuilt and seems likely to be of use in judging the effect of artificial finishes such as waxing, french polishing, etc., on the natural surfaces left by the plane. Some preliminary results have been obtained on the effect of a wax polish on the "finish" of oak, in which measurements were made on the scattering of light by (1) the untreated hand-planed surface, (2) the same surface when wax polished and (3) the waxed surface after rubbing with turpentine. To the naked eye surfaces (2) and (3) are almost indistinguishable, but it was observed that the normal reflection was reduced by about 25 per cent. by the turpentine, whereas the normal reflection of the unpolished surface was less than one-half that of the waxed. The amount of scattered light was, however, almost the same in each case. It is also proposed to use this apparatus to measure the possible effects of insecticides on the polishes and paints commonly used on wood.

Moisture Relations of Wood

The study of the amount of water held in wood by molecular sorption as distinct from that held by capillary forces has progressed during the past year, and the results have been published.[1] It has been shown that unless the degree of adsorption by the wood of the indicator (sucrose) is known, it is only possible to define a lower limit to the adsorption of water and that the true value may lie anywhere between this lower limit (which assumes no adsorption of sucrose and a maximum value for capillary retention of the water) and the total water held by the wood as shown by the vapour pressure isothermal (assuming a maximum adsorption of sucrose and no capillary retention of water). The lower limit for sorption of water appears to be about 23 per cent. of the dry weight of the wood in the case of Sitka spruce, but owing to the possibility of bacterial action on the sugar the time of the experiment was purposely kept short (2 to 24 hours) and hence a possible objection to the method remains, namely that sufficient time had not been allowed for sorption equilibrium to be set up. This point is now being investigated.

The above work led to the need for an accurate knowledge of the total water-holding capacity of wood in high humidity conditions

and particularly in a saturated atmosphere. The vapour pressure-moisture content isothermals of Sitka spruce and beech have therefore been determined for relative vapour pressures between 80 per cent. and 100 per cent. by a method which enabled the moisture content of the wood to be raised or lowered in small steps between wide limits by free distillation of water on to, or off, the wood. This has made possible the study of the desorption or drying process from moisture contents which represent complete saturation of the cell spaces, and it has been confirmed that a measurable drop in vapour pressure occurs on desorption at a moisture content of about 90 per cent. It is suspected that this may account for the appearance of shrinkage at high moisture contents on drying wood, even under conditions which should minimise the risk of drying stresses. Measurements

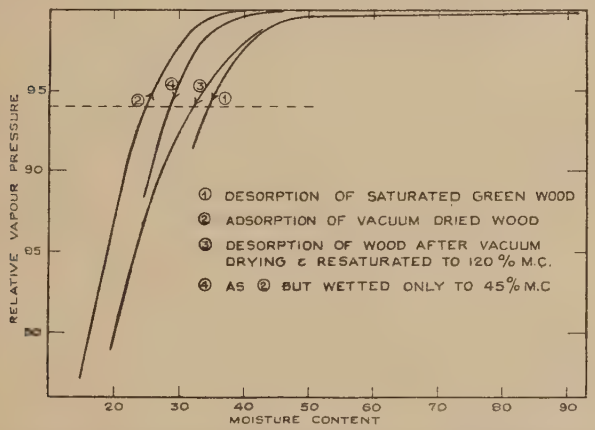


FIG. 1.—*Vapour Pressure-Moisture Content Isothermals for Beechwood at* 23° C.

are now being made by the Seasoning Section on the shrinkage of thin samples of beech. It is hoped to be able to correlate this shrinkage with the desorption vapour pressure values mentioned above.

These determinations of the vapour pressure isothermals have also brought out clearly the effect of pre-treatment on the hygroscopicity of wood, since the shape of the desorption curve at high relative vapour pressures is influenced by the moisture content from which drying commences. It is also found that the first curve obtained with the natural wood is not reproducible once the material has been completely dried, even without heat. As in the case of natural cotton[2] the effect of drying is to reduce the subsequent water-holding capacity of the wood at any given vapour pressure. Thus the equilibrium moisture content at any vapour pressure may lie anywhere between two extreme values.

As an example of the total variation possible when these effects are combined one may cite the case of beech (Fig. 1), which at 94 per cent. relative humidity has a moisture content of about 35 per cent. for desorption of a green sample which has been completely saturated (120 per cent. moisture content) (Curve 1) and about 25 per cent. for adsorption after it has been vacuum dried (Curve 2). If the same sample is now again completely saturated and dried once more to 94 per cent. relative humidity, the moisture content will be in the neighbourhood of 32 per cent. (Curve 3), but if the rewetting had been stopped at a moisture content of 45 per cent. the equilibrium value on redrying to the same relative humidity would be about 29 per cent. moisture content (Curve 4). The influence of pre-treatment becomes progressively smaller as the vapour pressure is reduced.

Last year's report also mentions an enquiry into the effect of external mechanical pressure on the vapour pressure exerted by moist wood, and this has been developed in the year under review. Katz has shown by thermodynamical reasoning that if a swelling gel is subjected to an external pressure, the vapour pressure of the water in the gel is raised. This has been shown experimentally by Jordan-Lloyd and Moran on gelatin. The same must be true of wood, but owing to its open structure and plastic properties it is not a suitable material for experimental verification. It was thought, however, that the low value of the fibre saturation point indicated by the effect of moisture content on the strength in compression might be accounted for in this way. The strength of wood in compression parallel to the grain is virtually constant for all moisture contents above a certain limiting value, whereas below this value the strength increases rapidly with fall in moisture content. This critical value (called the intersection point) is for Sitka spruce at about 26 per cent. moisture content, whereas the fibre saturation point is certainly above 35 per cent. and probably at least 40 per cent. If we assume that the strength of wood is determined not so much by the moisture content as by the vapour pressure which that moisture exerts, we can qualitatively explain this discrepancy, because a sample at 25 per cent. moisture content (normally exerting a relative vapour pressure of 95 per cent.) will in the testing machine rise in vapour pressure to saturation, provided it is strong enough to withstand the external pressure necessary to produce this change. From this it follows that the stronger the sample under test, the greater will be the vapour pressure change produced before it collapses, or in other words, a stronger sample may be at a lower initial moisture content and still reach saturation before collapse. Thus, groups of samples possessing greater natural strength should tend to give lower values of the intersection point. This theory has been tested on some very precise results obtained by Wilson[3] for the maximum crushing strength of Sitka spruce, and is found to be very well supported. Further support is given by a study of the intersection points obtained on all the softwoods so far tested at this Laboratory, which

show a marked tendency for high strength values to correspond with low moisture contents at the intersection points. The correlation is particularly good in the case of the firs (Fig. 2).

Attempts have also been made to discover evidences of the rise of vapour pressure under compression parallel to grain by studying the stress strain curves for beech. There appears to be some evidence that the compressibility increases slightly with increase in load, but it remains to be seen whether further progress can be made along these lines.

(1) Barkas, W. W. Wood Water Relationships : (I) Molecular Sorption and Capillary Retention of Water by Sitka spruce Wood. *Proc. phys. Soc.*, 1936, **48**, 1–15.

(2) Urquhart, A. R. *Shirley Inst. Mem.*, 1929, **8**, 29.

(3) Wilson, T. R. C. *Tech. Bull. U.S. Dep. Agric.*, 1932, No. **282**.

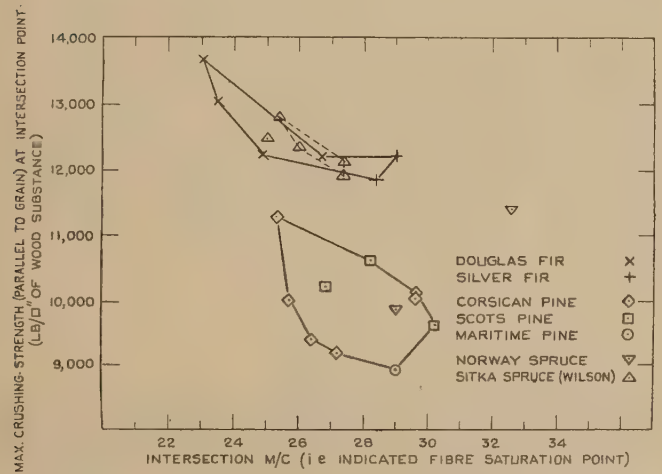


Fig. 2.—*Relation of Maximum Crushing Strength to Apparent Fibre Saturation Point of Softwoods.*

Moisture-proof Coatings

In order to discover a relatively efficient moisture-proof coating for use in a further experiment, some simple tests were carried out on a few usually recommended coatings, such as shellac varnish and lead foil. The results showed the great superiority of a gloss oil preparation made to a formula published by the Forest Products Laboratory, Madison, in Technical Note 186 and used to prevent end checks while seasoning. The superiority is evidenced by the following figures which are relative rates (in arbitrary units) of loss

of water through cylinders of wood coated in the manner detailed. The conditions are not specified but were identical for all.

A. 1 coat soft wax, 1 coat varnish	144
B. 1 coat varnish, 1 lead foil, 1 soft wax ..	124
C. 1 coat soft wax, 1 varnish, 1 gloss oil ..	36
D 2 coats gloss oil	57
E. 3 coats gloss oil	20

Measurement of the Moisture Content of Wood

The oven-drying method of moisture determination has always been regarded as slow, and periods as long as twenty-four hours have been cited as the time for the thorough desiccation of a sample. Actually, the results can be obtained to a degree of accuracy within $\frac{1}{2}$ per cent. of the correct value in from two to three hours with a sample $\frac{1}{2}$ in. thick in the direction of the grain, or in half this time if the piece is but $\frac{1}{4}$ in. thick. This applies to timbers such as beech in the air-dried state (about 25 per cent. moisture content). Oak and similar woods require three to four hours. The times may be doubled if the samples are crowded into the oven or if the ventilation is insufficient, but this would not usually arise if results were required urgently. Experiments were made under normal conditions in a small ventilated oven heated by electric light bulbs, and not in any special dryer. The method of obtaining samples by boring with a brace and bit has proved reasonably accurate when applied to boards in the process of kiln-drying. If the boring is taken from the edge of the plank to a depth equal to half its width, the moisture content obtained will be approximately the average of the section.

The Relations between the Moisture Content of Wood and the Surrounding Hygrometric Conditions.

Investigations into the behaviour of wood in relation to the surrounding atmosphere are continuing. Earlier experiments[1] had indicated that the moisture content assumed by a sample depended on whether it approached the equilibrium state by a drying or a re-wetting process. It appeared that at any given temperature the particular moisture content would lie in the zone bounded by the curve followed by the timber in drying from the green state and that obtained during re-wetting after complete desiccation over phosphorus pentoxide.

A later experiment demonstrated that the range in most cases is unlikely to be so wide as this, for the lower bounding line is the adsorption isothermal drawn from the lowest humidity value in a particular cycle. Fig. 3 illustrates the two extreme boundaries and the behaviour of three sets of samples which, after drying to the steady state at 30 per cent. humidity, were re-wetted to the steady state at 50 per cent., 70 per cent. and 90 per cent. humidity respectively and then re-dried by stages again to 30 per

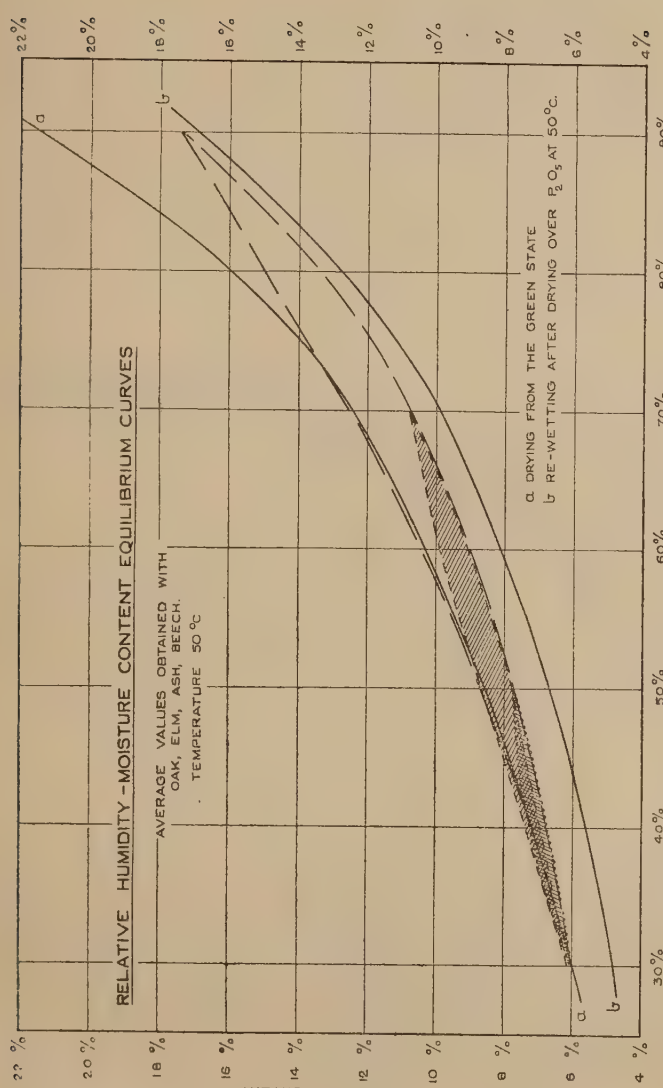


FIG. 3.—*Relative Humidity-Moisture Content Equilibrium Curves for Oak, Elm, Ash and Beech.*

cent. humidity. The three adsorption curves from this point coincide within the limits of experimental error.

The storage of kiln-dried timber in a comparatively damp situation is frequently unavoidable, and the ensuing moisture regain may be sufficient to cause serious shrinkage later when the timber has dried subsequent to its installation in a drier environment.

Fig. 4 shows the amount of moisture absorbed by hardwood flooring when stored in an unheated shed during the autumn and winter months. The upper zone depicts the range of regain in timber open-piled in stick, and the lower area indicates the behaviour of bulk-piled material without sticks. This latter does not, of course, include the outer pieces of the stack, for these

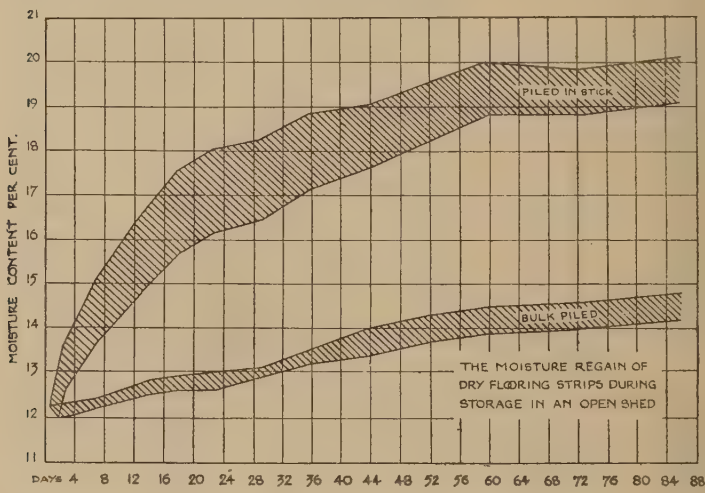


FIG. 4.—*Moisture Regain of dry Flooring Strips during Storage in an open Shed.*

absorbed moisture almost as quickly as the strips separated by piling sticks. It is not suggested that such material would normally be open-piled in stick, but the comparison between the two methods indicates the advantage of really close stacking. The curves for the bulk-piled timber enable the amount of regain in a given time to be gauged. It is proposed to continue this work and extend it to cover different sizes and classes of timber used for general interior work.

The examination of the moisture content conditions of timber in new buildings is being continued, and the results so far obtained have been summarised in a Laboratory publication[2]. Sufficient data have been accumulated to describe the general fluctuation of the moisture-content of woodwork in a large building. Fig. 5 shows the

conditions from the completion of the roof, through the drying-out process to occupation. It illustrates the effects of the needless and wasteful process of " baking " the building in the belief that a new structure must necessarily be damp and unhealthy. The restoration of normal heating and ventilating is marked by the return of the timberwork to an average yearly moisture content of about 12 per cent. It will be realised that the period required for the drying out of the building will depend on factors such as ventilation, the amount of heat applied and the period of the year. The time shown in the Fig. 5 must not therefore be taken as of general application. Among the buildings at present under test is the house at Burhill, Surrey, presented by the Warrant Holders as a Jubilee gift to His late Majesty, King George V. This house is of particular interest as it represents building under the most favourable conditions as regards both materials and time.

Hitherto, the moisture and dimensional changes of timbers have been measured on comparatively small pieces which remained in, say, an office or an unheated store for a year, observations being taken at monthly intervals. This has proved only partially satisfactory, for the climatic variations between one year and another have made difficult any definite comparison between species. A considerable improvement has been effected by using larger and thinner samples which are conditioned in constant humidity rooms. The moisture gradients, even though very small, were troublesome in the old method, but these are eliminated by the new technique. At present, a dozen species of timber are under test, and an examination of the causes of variation in shrinkage is being undertaken. It is realised that " movements " with changing atmospheric conditions will vary considerably within any one species, and as opportunity occurs it is proposed to obtain samples from various trees of the same species from several localities and from different positions in a single tree.

It is well known that the inside portions of very large hardwood timbers dry extremely slowly and cases are frequently mentioned of beams of great age taken from old buildings which obviously still contain much moisture at the centre when sawn. Tests which have now been made in Westminster Hall and in the Parish Church at Thame, Oxon., have served to place an upper limit on the time required for thorough seasoning of large oak beams. The moisture distribution in timbers as large as 20 in. × 15 in. in dimension and dating from the XVth Century has been found to be uniform from skin to core. Some tests are in progress at the Laboratory on the drying of 12-inch squares of oak stored in the open air under cover. The distribution of moisture is being tested at intervals of six months.

(1) KNIGHT, R. A. G., and PRATT, G. H. *Engineering*, 1935, **139**, 472–3.

(2) *Forest Products Research Records*—No. **5** (*Seasoning Series No.* 2).

(1) The curve shows the expedition of the drying process by means of temporary heating.

(2) Additional heat applied during early occupation with the object of still further drying out the building has little permanent effect, for reabsorption of moisture occurs when normal conditions are established.

(3) It has been found by experiment that the mean yearly moisture content of joinery in a matured centrally-heated building is about 12%, and that the variations in summer and winter are usually no greater than ± 2%.

FIG. 5.—*Moisture Content Conditions of Timber installed in a new Building*

The Effect of Moisture Content on Strength

The routine tests on small clear specimens for preparation of the curves showing the effect of moisture content on the strength properties have been completed for almost all the consignments of timbers so far received from this country and from the Colonies. Data have also been supplied to the Section of Timber Physics for the purpose of analytical work.

The Shrinkage of Wood

In the report for 1934 mention was made of a project to study the relation between the shrinkage of wood during drying and the subsequent "working" when subjected to changing atmospheric conditions. Tests carried out during the year have shown that for moisture contents below about 20 per cent. the shrinkages and "working" movements per unit change in moisture content are practically identical. In tests of this nature effects due to drying stresses are reduced to a minimum and the temperature is kept constant throughout.

These tests have further indicated that shrinkage probably commences at moisture contents as high as 40–50 per cent. and that appreciable shrinkage may have occurred by the time the wood has dried to the generally accepted fibre saturation point, lying between 20 and 30 per cent. moisture content.

It is well known that the stresses which develop during drying influence the behaviour of the wood both during the seasoning process and subsequently. With a view to assessing the effects produced, some experiments have been put in hand which aim, in the first instance, at developing a suitable technique for measuring the strains and "sets" produced by these stresses. An attempt is being made to measure both the temporary and permanent strain in thin cross-sectional strips cut from "casehardened" or stressed planks, by comparing their lengths with closely matched specimens dried to equivalent moisture contents without restraint.

The effect of such strains upon the shape and size of dried planks is being studied, as are also the methods of relieving the latent stresses by means of storage over long periods, steaming treatment and other expedients.

Kiln-seasoning Experiments

A comparison of various methods of kiln operation is being made and 2-in. beech is being used for the experiments. The methods include oscillating the temperature and humidities at short intervals, periodic reversals of the air circulation, and shutting down the kiln at night. Preliminary results indicate that none of these treatments shows any marked advantage over the usual method of operation. Shutting off the kiln for a part of the day results in the timber having to be retained in the kiln for a longer period than with continuous running, but there appears to be a

saving in time during which the kiln is running and in steam consumption. Confirmation is, however, necessary before the findings can be published. In continuation of the work on imported timber, experiments on American oaks have been made. It appears that a much higher temperature can be employed than is believed to be safe for English oak and the drying time can thus be reduced very appreciably.

An intermittent treatment, devised by S. N. Kapur of Dehra Dun, has been applied to beech and Polish oak, but seems to affect no reduction in drying time compared with continuous seasoning as far as these species are concerned. There may, however, be a saving in the amount of steam taken by the kiln.

The species kiln-seasoned during the year include home-grown beech, Carpathian beech, sweet chestnut, Polish oak, American red oak, American white oak, Sitka spruce, Dutch elm, English oak, teak, Scots pine, and spruce (box shooks), ash (tennis racket veneers), Santa Maria (*Calophyllum brasiliense* var. *Rekoi*), nargusta (*Terminalia* sp.), white olivier (*Terminalia* sp.), mvule (*Chlorophora excelsa*), cramantee (*Guarea excelsa*), timbersweet, and cypress (*Podocarpus guatemalensis*).

The Influence of Kiln-seasoning upon the Mechanical Properties of Timber

Experiments have been initiated to examine the influence of different methods of kiln-seasoning upon the mechanical properties of timber. These comprised mechanical tests on home-grown beech subjected to seven different kiln-seasoning treatments. The mechanical tests on the seven groups of kiln-seasoned material have now been completed.

Comparisons of the strength properties of the beech subjected to these drying treatments will be made on matched air-dried material as soon as the standard moisture content has been reached.

Tests have been made on Carpathian beech from Roumania which has undergone kiln-seasoning. The mechanical tests on the kiln-seasoned material, which was in the form of 3-inch planks, have been completed. The corresponding matched air-dried material is now undergoing conditioning prior to testing.

Experiments have also been commenced to investigate the effect on the strength properties of partial kiln-seasoning from 25 per cent. to 10 per cent. moisture content of 1-inch boards of imported American red oak and American white oak. In addition, the effect of rapid drying by high temperatures is being examined. In the latter case, the results of tests made so far indicate a probable reduction in shock resisting ability. The investigation is continuing.

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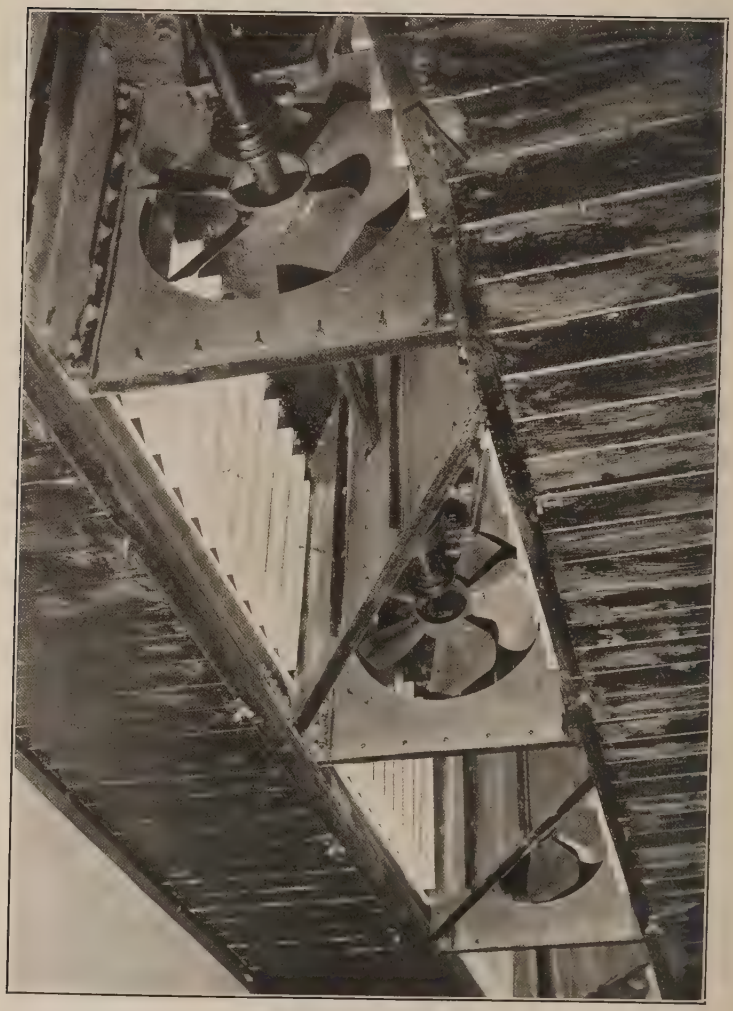
PLATE II



The Cross-circulation Kiln.

View from below of the vertical baffles or slats that deflect the air more truly across the kiln.

Kilns

(*a*) Heat Losses in Kilns.

A direct reading " Blackie " surface heat-flow measuring instrument has been obtained and tests have been undertaken to determine the losses through walls, doors, roofs and floors of kilns, both when comparatively dry and after being subjected to high humidity conditions for considerable periods. It is hoped by this means to determine the decrease in the insulation properties of kiln materials with increase in moisture and so to determine the efficacy of various kiln materials and paints, when subjected to normal working conditions.

(*b*) Alterations and Extensions to Seasoning Plant

In many experiments on the mechanical and physical properties of timber, the samples must be conditioned to a particular moisture content in an atmosphere of constant temperature and humidity. Of late, this class of work has increased in volume and it has become inconvenient to produce the conditions required in desiccators or small ovens as was formerly the practice, and the construction of large constant humidity rooms is in progress. One of the kilns has been divided into three compartments, in which humidities of 90, 60 and 30 per cent. respectively will be maintained, the temperature being kept constant at 25° C. The 90 and the 60 per cent. rooms have been completed and the 30 per cent. compartment will be finished early in 1936. In each room, the bulk of the heating is by steam pipes with thermostatically controlled electric heaters to secure final steadiness. Water atomised by air spray is used to humidify the 90 per cent. and 60 per cent. chambers, the air supply being adjusted automatically by motorised valves connected to hair-type humidostats. Drying and not wetting of the air is required in the 30 per cent. room, and silica gel is being utilised for this. Here again, the process will be under automatic control. Very close uniformity of conditions is being obtained, and the humidity rooms are proving of very great service. Experiments on a scale hitherto impracticable are projected, and the general work on the moisture relations of timber is now rendered independent of the climatic variations, which previously delayed or spoilt many experiments.

The lack of uniformity of air movement in the Cross-circulation kiln, referred to in last year's report, has been largely rectified by fitting vertical slats 8 in. wide and 4 in. apart by the side of the fans to deflect the air into streams running at right angles across the kiln. The inequality of air speed between one end of the kiln and the other has thus been much reduced without resort to any but a simple form of baffling (*see* Plate II).

The covered pit in which kiln conditions can be reproduced for the testing of paints has been improved so that the extreme range of temperatures and humidities met with in kilns can be

obtained. Investigations leading to the establishment of a standard accelerated test cycle have been carried out. The pit has also been used to produce high humidity-low temperature conditions for the testing of fungicidal paints.

The overhead internal fan kiln constructed some years ago, which has given such satisfactory results, is being reconstructed. Originally the kiln was provided with a wooden roof, but it was found that severe steam leakage occurred. A concrete roof has now been built and the heating coils and mechanism will in future be suspended from the roof, access being obtained from below instead of above as hitherto. In the reconstruction it is proposed to use sheet metal for the fan trunk and baffles, and the fan diameter will be increased from 18 in. to 2 ft.

Wood Bending

Investigations into the bending qualities of Dutch elm, sweet chestnut and Norway spruce have been completed during the year and similar tests on birch, sycamore and horse chestnut are in progress. The Dutch elm proved to be an excellent bending timber but the Norway spruce was found to be very prone to buckling and hence unsuitable for bending in general. Sweet chestnut buckled and fractured on the inner face of the bend when much moisture was present, and knots, even of the smallest dimensions, tended to aggravate this weakness of the compressed layers. When the timber was air-dried, however, it was rendered very much more suitable for bending, but knots were still found to cause trouble.

Small scale investigations have been carried out on the bending qualities of the following Empire timbers: timbersweet, mansonia (*Mansonia altissima*), karri (*Eucalyptus diversicolor*) from native and South African sources, Turkey oak, nargusta (*Terminalia? obovata*), and three species of ebony. Of these, the oak and ebonies were all found to be very good bending timbers, whereas the karri both from South Africa and Australia, although suitable for moderately severe bending, was rather prone to buckling. The other timbers tested were unsuitable for bending, being generally too weak in compression.

A series of tests to determine the best methods of drying and " setting " bends has been put in hand and it has been found that the two terms are by no means synonymous. The behaviour of " set " bends when subjected to fluctuating atmospheric conditions is also being studied, and it has been demonstrated that the radius of curvature alters appreciably according to the changes in the moisture content of the test piece. Subsidiary tests have further shown that wood when compressed longitudinally and " set " in this state, shrinks and " works " very appreciably in the longitudinal direction. Such movements, combined with the movement of the cross-section, would account for the alteration in curvature noted.

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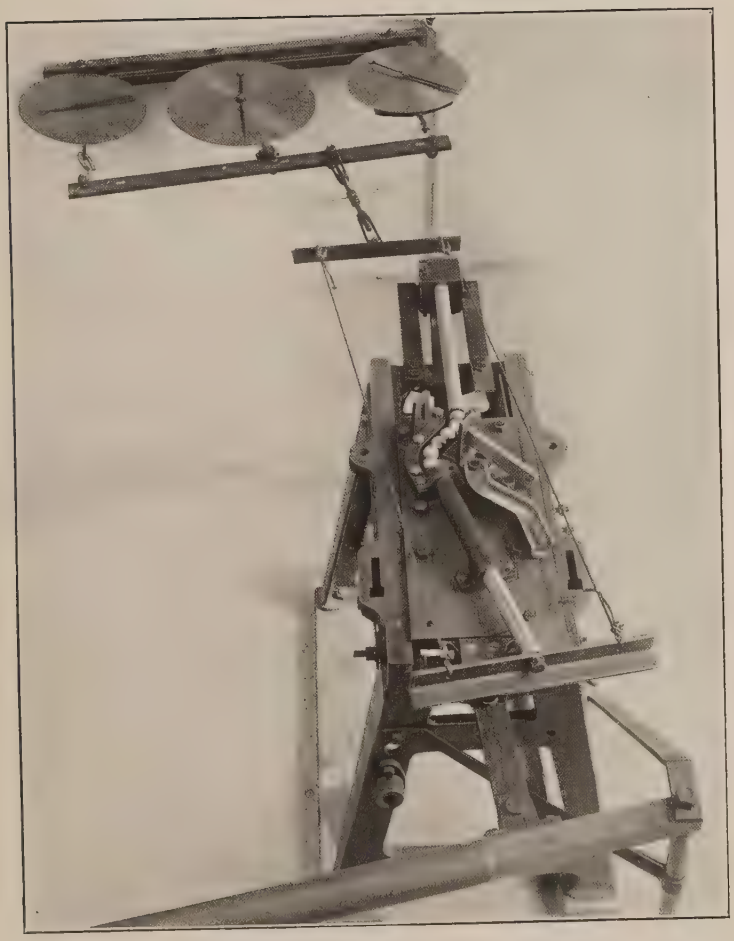
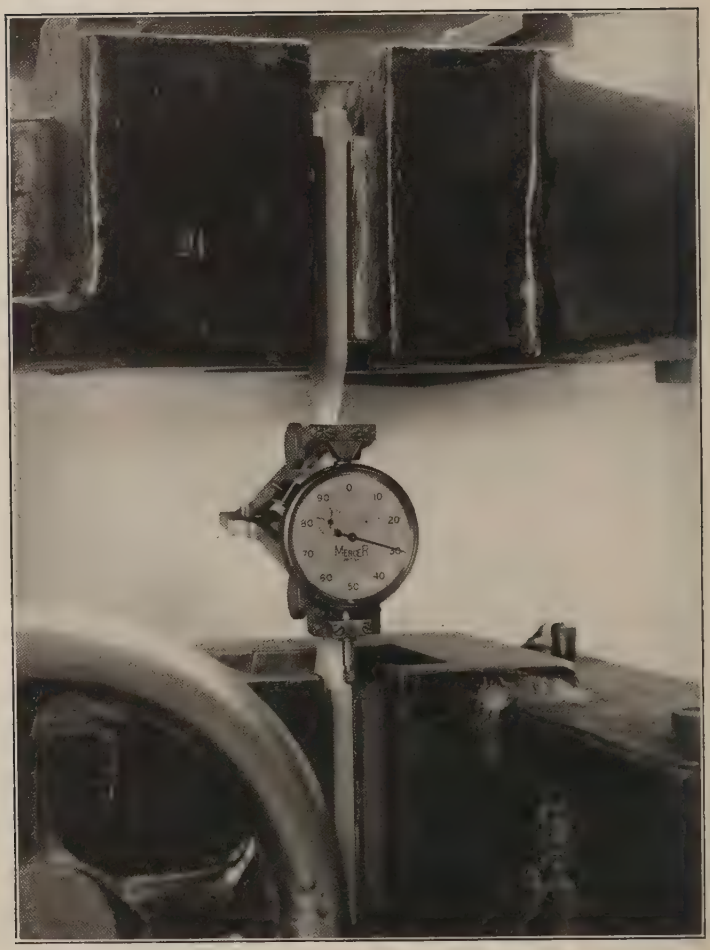
PLATE III



Machine for bending Shovel Handles.

PLATE IV



Extensometer for Tension Tests of Steamed Wood.

Special work in connection with the bending of hockey sticks, tennis racket and furniture parts, has also been undertaken.

Plate III shows a machine designed and built at the Laboratory primarily for the purpose of making the double S bend at the ends of ash shovel handles. This machine incorporates an end-pressure device by means of which the pieces can be subjected to considerable longitudinal pressures during the actual bending process.

Comparative tests have shown that although the possibility of fractures occurring is not entirely eliminated, a much greater percentage of flawless bends may be produced by this method than by the standard type of machine usually employed, and that the total number of rejects may be greatly decreased.

Straps and apparatus for making bends in two planes with the aid of the existing bending table have been designed and are being tested. Many small alterations in the design of straps and end fittings have been made with the object of rendering the existing bending machine more adaptable to general commercial purposes.

Mechanical Tests on Steamed Wood

Tension and compression tests on steamed wood for the evaluation of comparative bending quality have been carried out on thirty-four species. The extensometer evolved for use in tension tests is illustrated in Plate IV.

Special compression tests on steamed beech have been carried out to determine the influence of steaming time on the wood, and also the variation to be expected between matched specimens.

Tests have been commenced, using a compression specimen $1\frac{3}{4}$ in. $\times$ 1 in. $\times$ 1 in., to determine the rate of setting of steamed wood held in compression and the effect of different factors on this rate. The tests so far have been concerned mainly with the development of the technique of testing and the apparatus necessary. These preliminary tests have been satisfactory and further tests are projected.

It is desirable to know to what extent cooling during test influences the results obtained from a compression test on a steamed specimen. An apparatus has therefore been designed to enable the specimen to be steamed during the test. It is hoped by this means to determine the effect of cooling and if necessary to eliminate it in future tests.

Tests of Timber in Structural Sizes

A comparison of the strength of different species or of different consignments of the same species of timber in structural sizes is complicated by the presence of defects either natural or induced, and it is essential that such comparisons should only be made between joists of the same size and having defects of similar size, nature and frequency.

As a preliminary to the analysis of the causes of degrade, an attempt was made to correlate the many grading rules that exist. This correlation was found to be impossible since a number of the rules were loosely worded and admitted of widely different interpretations.

Further it was found that numerous different standards of grading exist in the countries lying round the Baltic, but that in only one instance are the specifications printed.

The only graded material tested at the Laboratory was supplied from Archangel and Gefle and from an analysis of these consignments values were established of the size and occurrence of defects in the five grades. On the basis of this analysis, a tentative system of grading was prepared by which consignments of unsorted joists might be graded to approximately the same standards as these two consignments. It is hoped that it will be possible to augment these data by further inspections of graded material from other North European districts. Owing to the widely different characteristics of other species, this system of grading is not applicable to all timbers and will require further modifications before it can be generally applied. Information on the natures of other species and of other consignments of the same species has been obtained by an analysis of all the joists that have been tested in the past and a detailed analysis is now incorporated in the routine.

During the past year, testing has been carried out on seasoned joists of the following consignments :—

Douglas fir from British Columbia.

Spruce from Eastern Canada.

Redwood (Scots pine) from Hudiksvall, Sweden; Kemi, Viborg, Kotka, Finland; Longleat, Wiltshire.

Honduras pitch pine (*Pinus caribaea*) from British Honduras.

Data on the strength properties of redwood from Archangel and Gefle have been published in Forest Products Research Records —No. 2. A further report in this series [1] is at present in the press and concerns Douglas fir from British Columbia. This consignment was selected from a commercial shipment of the "merchantable" grade. On account of the different nature of this timber and its defects it was not practicable to regrade according to the approximate Baltic standards. The next report, which will be on the Eastern Canadian spruce, is expected to be ready for publication early in 1936.

[1] *Forest Products Research Records*—No. 8 (*Timber Mechanics Series No.* 2). Strength Tests of Structural Timbers. Part 2. Procedure of Selecting and Testing Joists, with Data on British Columbian Douglas Fir (*Pseudotsuga Douglasii* Carr.).

Home-grown Timbers

(*a*) Strength Properties of Home-grown Timbers

Tests on two further consignments of home-grown timber have been commenced during the current year in order to supplement existing data. These consignments, which have been tested in the green condition, consisted of sycamore and European larch.

(*b*) Tests of the Strength of Poles of Home-grown Timbers.

As forecast in the Annual Report for 1934, the report of the strength tests of home-grown poles has now been completed. Of the three species tested, Corsican pine was found to be a satisfactory substitute, so far as strength is concerned, for imported redwood poles of the same size. Sitka spruce and Norway spruce on the other hand proved inferior in strength to redwood, the difference being very pronounced after creosoting. This latter result is ascribed to breakdown in the micro-structure of the wood under the creosoting pressure, which, on account of the low permeability of the wood, has to be maintained for a longer time and also takes longer to release. Certain of the spruce poles were incised prior to creosoting but no differences in strength on this account were detected.

(*c*) Creosote Treatment of Home-grown Transmission Poles

In co-operation with the Forestry Commission an investigation has been undertaken with the object of assisting the marketing of advanced thinnings of home-grown timbers as transmission poles. At present the species used for this purpose is redwood, mainly imported from the Baltic countries, together with a certain amount of home-grown material. From the aspect of preservative treatment this species is very satisfactory. There are, however, several other species which will shortly be available in pole size and the tests were undertaken to ascertain the suitability of these species for poles. So far Corsican pine, Norway spruce and Sitka spruce have been investigated.

The Post Office specifies that the treatment applied to transmission poles should inject a minimum gross amount of creosote of 12 lb. per cubic foot and effect a complete impregnation of any sapwood present. This is readily accomplished with Baltic redwood, which contains a very convenient proportion of sapwood (approximately 1/3 of radius), by a short Empty Cell process which gives an absorption of about 4–6 lb. of retained creosote per cubic foot. Corsican pine poles with a similar sapwood content could be treated with equal efficiency, but the proportion of sapwood in this species is higher, the consignments supplied containing over 90 per cent. The experiments showed that with this very high percentage, complete sapwood impregnation and low net retentions were incompatible. As the initial air pressure of the Empty Cell process was increased to reduce the net retention to an acceptable figure, the volume of impregnated sapwood decreased. Alternatively,

the maximum air pressure consistent with complete impregnation was found to result in a high net retention. When air was applied above this critical pressure its volume in the final state, being in excess of the heartwood volume, apparently accumulated in part of the sapwood thus inhibiting complete impregnation. The investigation demonstrated that the cost of treating Corsican pine with so large a sapwood proportion, to the Post Office Specification, would be higher than that for Baltic redwood, owing to the higher absorption of creosote, and, further, that the cost increases more rapidly than the proportion of sapwood when this latter exceeds 70–80 per cent. of the total amount of wood. The service tests may show, however, that the untreated sapwood present in poles treated to a net retention of 8–10 lb. per cu. ft. does not seriously endanger the life of the poles.

Processes have been formulated which are adequate for the injection of the specified gross amount for both Sitka and Norway spruce, but in both cases the treatments were much longer than that applied to Baltic redwood, especially in the case of Sitka spruce. Both the Empty and Full Cell processes investigated with respect to these species had their attendant disadvantages. An Empty Cell treatment, while permitting low net retentions, required a long application period and left the surface of the poles in a wet condition, probably unfit to erect for several weeks. Alternatively, a Full Cell process was much shorter and produced clean poles, but retained too high a net weight of creosote if reasonable penetration was obtained.

Incising has been found to reduce appreciably the time of treatment of poles of these species, and with the Empty Cell process to reduce slightly the net retention. It has also been shown that the extensive splitting, a serious drawback to the use of spruce poles, can be reduced by incising before seasoning. It has been concluded that neither Norway nor Sitka spruce compares favourably with either Corsican or Scots pine for the purpose of transmission poles, but in cases where deep splitting and " dirtiness " of the poles are not objected to it is possible that they can be used satisfactorily.

During the investigation of Norway spruce a number of irregular and unexpected results were obtained : for instance, the effect of incising on the gross absorption during two identical Empty Cell treatments was widely different. These irregularities were subsequently correlated with the presence of brown-stained wood in about half of the consignment. This stain is attributed to the attack of the fungus *Stereum sanguinolentum*, and comparison of stained and unstained poles showed that considerable reduction in resistance to impregnation may result from a condition induced by or associated with this staining fungus (Plate V). It appears probable, therefore, that the variation in the resistance to impregnation so often found

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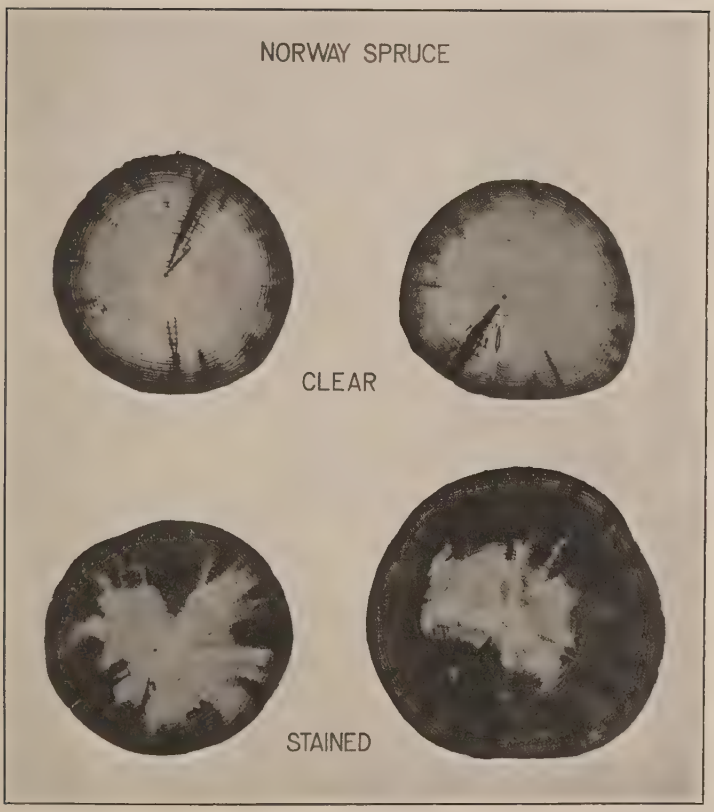
PLATE V



Cross-sections of Poles showing the Effect of Staining Fungus (Stereum sanguinolentum) *on the Penetration of Creosote into Norway Spruce.*

in Norway spruce may be largely due to the attack of this fungus either in the tree or during seasoning.

This susceptibility of Norway spruce to attack cannot be considered advantageous when its properties for transmission poles are estimated, for, although antiseptic treatment may be expedited, the penetration of creosote is very irregular and any reduction in mechanical strength which may ensue from its development is undesirable in a timber which normally has not a high strength value.

(*d*) Cricket Bat Willow

In continuing investigation on this timber, many difficulties were encountered, especially in connection with the " playing " test carried out by professional cricketers, the results being in the form of their comments on the playing characteristics of the bats. A " rebound " test was devised at the Laboratory and an attempt made to relate the results to those of the playing test without success. It was not found possible, therefore, to assess in any way the value of this laboratory test as a means of grading the clefts on a basis of playing qualities.

(*e*) Home-grown Timber for Street Paving

A preliminary survey has been made during the year of the conditions governing the use of wood for street paving. The co-operation of paving manufacturers, contractors and borough engineers has been enlisted, and as a result of this investigation much information has been collected as to the quality and specification of timber used, the methods of laying and the serviceability of wood as compared with competing materials.

It is estimated that not less than five million cubic feet of timber are used annually for new work and replacements, and since the whole of this timber is imported, this field merits further investigation as a potential outlet for home-grown timber. Inspection of the imported paving wood and analysis of the specifications used by a number of borough authorities indicate that home-grown Scots pine has no inherent disadvantages as compared with the Scots pine commonly imported from Europe for this purpose.

The contacts made with municipal authorities have already resulted in a definite proposal to lay a trial section of home-grown pine paving within one of the boroughs.

(*f*) The Pulping Properties of Home-grown Spruce

The suitability of certain home-grown softwoods for pulp for raw material in the manufacture of paper, wallboards and other pulp products is likely to be a prime factor in the disposal of thinnings and low grade timber. Exact data have so far been lacking as to the relative suitability of home-grown Norway spruce grown in different localities and under different conditions—information of

the utmost importance in view of its possible bearing on silvicultural policy. With the co-operation of the Forestry Commission, representative logs of Norway spruce were collected from various parts of the country, covering eight localities and soil formations. Information as to the conditions of growth and locality was recorded in the fullest detail. On arrival at the Laboratory, the samples were examined and various structural details recorded. Bolts of commercial size representing each locality were forwarded to a firm of wood pulp manufacturers for an opinion as to the suitability of the wood. A note is now in preparation embodying the manufacturer's reports, together with the data obtained from the Laboratory examinations.

(*g*) The Properties of Home-grown Sitka Spruce

In view of the somewhat discouraging report on earlier consignments of home-grown Sitka spruce tested at the Laboratory, the Forestry Commission requested that the testing of a further consignment of timber considered to be more fairly representative of the species as grown under average conditions might be undertaken. In 1934 preliminary tests were carried out on timber from three localities, and on the advice of a London box manufacturer, the balance of the consignment was air-seasoned with a view to determining whether further maturing would improve the quality of the timber for box-making purposes. At the close of the year, logs of Sitka spruce were received for tests on behalf of the Government of Northern Ireland. These and the remainder of the 1934 consignment will be subjected to further laboratory tests and commercial trials in 1936.

The Resistance of Timber to Abrasion

Considerable progress has been made during the year under review towards the standardisation of an abrasion test for flooring timbers.

Exploratory tests leading to the adoption of "standard" abrading tools and procedure were completed, and a comprehensive series of experiments has been carried out to examine the possibility of obtaining a quantitative measure of the resistance to wear. Tests were made on hardwood flooring timbers, including Canadian maple, Canadian birch, home-grown beech, home-grown oak, Australian jarrah, Tasmanian oak, Burma teak, and Rhodesian "teak."

Species were arranged for test in a number of different groupings of three species per panel to determine if the wear of one species was influenced by the presence of others undergoing test at the same time. The results of these tests have proved satisfactory from a qualitative point of view, the wear and manner of breakdown in any one species being independent of the panel grouping. Quantitatively, however, the results were somewhat inconsistent,

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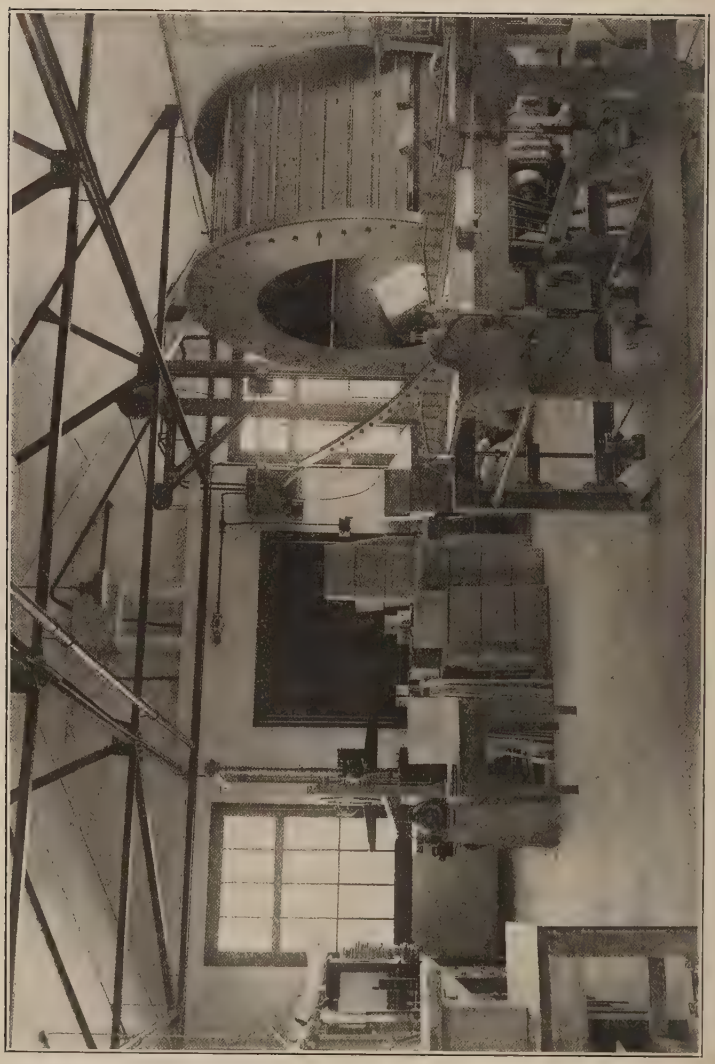
PLATE VI



A general View of the Box-testing Laboratory.

the amount of wear, as measured in this instance by loss in thickness, varying with the different arrangements of species on the test panels.

It thus appeared that to obtain a satisfactory quantitative measure would involve the testing of the species one at a time. A further series of tests using the same species as before and testing each one separately has now been completed. The results obtained point to percentage loss in weight as being a more satisfactory basis for comparison than loss in thickness.

It would appear, however, from a study of the variation in the manner of wear and breakdown in different species that a combination of both the qualitative analysis and the quantitative measure of wear would be the most reliable index for the comparative grading of flooring timbers.

Confirmation of the above results is being sought from a second series of tests now in progress, after which a complete series of standard tests on all flooring timbers is contemplated to grade them according to their wear-resisting property.

Tests on Plywood

At the request of the Sub-Committee of the British Standards Institution concerned with the drafting of specifications for the grading of commercial plywood, tests for compliance with the tentative specifications were carried out on plywoods of Douglas fir, birch and Australian hoop pine.

Box-testing

The box-testing laboratory building was completed and part of the testing equipment installed ready to begin operations early in April. A general view of the box-testing equipment is shown in Plate VI. The proposed laboratory had received some publicity in the technical press and in consequence requests for tests to be carried out were received from box makers before the new laboratory was ready to operate.

The equipment of the new laboratory consists of a tumbling drum or hazard machine, a crushing tester and a drop tester, all three of wh ch machines are used to test the box or package with contents. The minor equipment comprises a Mullen tester and a Schopper Dalen tester to test the bursting strength of paper, cardboard or fibreboard, an Elmendorf tester to measure tearing strength with and across the machine direction, and other apparatus for testing the characteristics of the materials used in packing goods, such as the resistance to water absorption, moisture content, weight and thickness. Although the drum was constructed to conform with the standard pattern, experience in working has shown that while the treatment which the box receives is such as to reveal any weaknesses which might result in damage to the contents in service, the severity of the test is liable to considerable uncontrolled fluctua-

tions even when applied to exactly similar cases. Consequently it was found impossible to assess in definite terms results of comparative tests. The design and operation of the drum are therefore being studied in detail and experiments are being carried out with a view to the elimination of this uncontrolled variation. A satisfactory solution is in sight.

An investigation was carried out on behalf of the Ministry of Agriculture and Fisheries with a view to designing a standard fibreboard case for National Mark eggs. Tests were carried out on a number of different designs of cases both of solid and corrugated fibreboard. A tentative specification for the minimum requirements for these boxes is now under consideration by the Ministry of Agriculture and Fisheries.

The Laboratory also co-operated with the Ministry of Agriculture and Fisheries in carrying out trials of fibreboard boxes in comparison with the standard type of wooden box for tomatoes. The tests showed that although the fibreboard box in some instances provided even better protection to the fruit in rough handling, there was doubt as to the adequacy of its strength under crushing loads and therefore of the height to which cases could be stacked. Service trials conducted by the Ministry confirmed the inadequate stacking strength of the fibreboard box, especially in those instances where a stack of boxes either in storage or in transit might be exposed to dampness.

Numerous tests have been carried out for private firms both manufacturing and using boxes. These tests were concerned with characteristics such as the resistance of certain fibreboard cases to collapse when bottles of liquid with which they were packed were broken, resistance to tearing of fibreboard when nailed to wooden frames at the end of specially designed boxes, and the influence of the arrangement of packages within the container in strengthening the " pack."

One interesting problem dealt with the damage occurring at the corners of cases packed with light composite containers holding powder. As a result of the investigations carried out an officer of the Laboratory has devised, and protected by a provisional patent, a novel arrangement of " pack " which is now undergoing service trials.

The Laboratory has also co-operated with the Government of New Zealand in carrying out tests on various designs of butter boxes. The tests were to determine the endurance of the container, and were carried out in the drum tester.

Woodworking Research

Routine testing under the Laboratory project " Investigation of the Working Qualities of Timber " as revised 1934, carried out during the year, has comprised five major scale and sixteen preliminary investigations of home-grown and overseas timbers, together with

various minor tests on fourteen additional species. In general, the behaviour of each timber under normal working conditions has been studied and, where difficulty has arisen in any operation, experiments have been made to determine the modifications necessary to the tool, speed or other factor to obtain satisfactory results. The determination of the most suitable shape and spacing of saw teeth and the correct cutting angle to employ with each of the timbers examined is normally included in these studies.

The work in connection with the sawing of timber containing silica or other abrasive material has been continued. Plate saws of high quality chrome-nickel steel with teeth of shape and spacing found by experiment to be best suited to this class of timber have been tested, both with normal temper at the tips and with specially hardened tips. Reasonably good results were obtained with these saws and an increase of about 17 per cent. in the output for each sharpening was gained by tip-hardening. An increase of this order was not sufficient, however, to counterbalance the extra trouble in sharpening and setting such teeth. With the most refractory timbers it has been found necessary to use saws having teeth tipped with tungsten-carbide, and excellent results have been obtained with teeth of this type both on inserted-tooth and plate saws.

The amount of power required to drive a saw is a useful indication of its efficiency as regards the suitability of the teeth for cutting the particular timber. Measurement of the power consumption also allows comparison to be made between different timbers. Of considerable additional value are data on the resistance to feeding. Hitherto, the power consumed in driving the saw has been measured only for hand feeding and difficulty has been found in keeping the feed sufficiently uniform in rate to provide consistent results. An experimental mechanical feed gear has been constructed, by means of which the necessary data can be obtained for designing an efficient feeding and recording device for feeding the timber to the saw and measuring the resistance to the feed. Preliminary tests have already given useful information concerning the rapid increase in power demand and in resistance to feeding as the saw teeth become dulled. Investigations to determine the inter-relationship of rate of feeding, peripheral speed of the saw, resistance to feeding and power consumption at the saw spindle are to be carried out when the apparatus is completed.

Experimental work on machining problems has been continued so far as time has permitted and methods of improving the finish from the machine in planing, moulding and other operations have been studied.

Too often, bad finishing is due to the use of blunt or badly set cutters, the desire to get through as much work as possible before stopping the machine to renew the cutting edges being generally the reason, though time and labour may be wasted through this

practice. It does not need research to prove the primary importance of using sharp, correctly ground cutters to obtain a good finish. Nor is confirmation required of the fact that a well-machined surface will always give results from polishing or other finishing treatments superior to those from a surface that needs much "sanding" after machining. Investigation of certain classes of timber, as for instance those with wavy, interlocked or other form of disturbed grain is necessary, however. These timbers are liable to "pick up" when planed and moulded in standard machines no matter how much care has been taken in sharpening and setting the cutting tools in the machine. A torn finish is generally caused, in such cases, through the angle at which the cutters are offered to the wood being unsuitable. If the angle (between the face of the cutter and the normal to the wood surface, *i.e.*, the cutting angle) is too obtuse, the chips are not broken before rifts can form below the surface of cut in those portions of the board where the cutters are moving against the grain. It has been found that reduction of the angle gives considerable improvement to the machine finish of timbers of this nature, with consequent saving in the final treatments, and better results. Data are already available as to optimum values of cutting angle from the view-point of finish for a number of timbers, but future work in this connection will include study of the interrelation of peripheral speed, rate of feed, power consumption, resistance to feeding and cutting angle. Improvement to the quality of the machined surface can also be obtained by giving a shearing action to the cutters either by placing them on the block askew to the axis of rotation or employing a helical form of cutter. The latter method is the more effective but there are many difficulties connected with the manufacture and grinding of cutters of this shape, and in holding them in the block, etc. Skew cutter blocks are in use and give excellent results when the angle of skew can be made sufficiently large. Consideration is being given to this subject and an experimental form of block with adjustment to both cutting angle and amount of skew has been devised.

Other practical studies have included trials of different types of pruning saws; the design and testing of steel frame bow-saws for felling and cross-cutting young trees in thinning operations; the design of a portable saw for ripping and cross-cutting logs on the felling site, the determination of safe feed-speeds in sawing joinery timbers, and of the power consumed on hand-fed saw benches; methods of determining the corrected profiles for moulding cutters; methods of silencing high-speed circular saws; finishing treatments for decorative timbers, and comparison of cutting edges of high-speed steel cutters obtained by wet and dry grinding. Machine and tool manufacturers and firms engaged in the woodworking industry have been visited for the investigation of special problems.

Woodworking practice and testing technique have been demonstrated to and discussed with members of the timber trade,

technical students, forest officers and other interested visitors to the Laboratory.

Wood Preservatives

(*a*) Standard Tests on Wood Preservatives

The inspection of specimens undergoing exposure in field tests has been continued and additional specimens have been laid down in connection with tests on one other preservative suitable for pressure application and eleven preservatives suitable for brush application.

(*b*) Laboratory Tests on Wood Preservatives

Agar and wood-block tests of the toxicity of a further number of proprietary and other wood preservatives have been carried out during the year. Many of these tests have been made on a repayment basis at the request of the manufacturers.

The possibility of establishing a standard test for determining the toxicity of wood preservatives in the laboratory has been discussed by a Committee of the British Standards Institution, on which the Laboratory is represented, and a panel has been formed to examine the details of such a test, which it is proposed shall be based on the standard test agreed to by the Committee set up by the International Conference in Berlin in 1930.[1]

In order that tests carried out in different laboratories shall be directly comparable it is important that, in addition to employing the same general method, the same isolations of the test fungi should be used, since different isolations of the same fungus species may vary in their resistance to antiseptics.

During the examination of a number of strains of test fungi from different laboratories it has been observed that the strain of *Fomes annosus* No. 517 of the Forest Products Laboratory, Madison, which has been extensively used as a standard test fungus in the United States of America, is entirely different from any other strain of *Fomes annosus* and, in fact, is not a culture of *Fomes annosus*. From the examination of a sporophore formed in culture and by comparison of cultures, it appears that it is actually a culture of *Polyporus tulipiferus* (Schw.) Overh. Results obtained with this isolation cannot therefore be compared with results obtained with cultures of *Fomes annosus*.

[1] Liese *et alia*. Toximetrische Bestimmungen von Holzkonservierungsmitteln. *Angew. Chem.*, 1935, **48** (21) (Beih. No. 11).

(*c*) Methods of Applying Wood Preservatives

A publication has been prepared describing non-pressure methods of applying wood preservatives. This is now in the press.[1]

Experiments have been carried out to determine the absorption of preservatives at various stages during the hot and cold open

tank process. It has been shown that practically no liquid is absorbed during the heating process, the heavy absorption occurring during the cooling period. If the charge is again heated a quantity of the absorbed liquid is expelled and if the timber is removed at this stage a considerable economy in preservative is effected. The penetration is equivalent to that after the first cooling, but the absorption is much lower. With absorbent timber, such as Scots pine sapwood, as much as 50 per cent. of absorbed creosote may be recovered, but with resistant timbers the amount recovered is much smaller. This enables charges of mixed heart and sapwood or absorbent and non-absorbent timber to be treated with more uniform results. It is, moreover, much more economical for the treatment of round posts of Scots pine, where the heavy absorption of creosote in the ordinary open tank process makes the treatment of this material very expensive.

[1] *Forest Products Research Records*—No. 9.

Durability Tests

(*a*) Field Tests of Natural Durability

Twenty-two further species of timber, mainly of Empire origin, are being subjected to field tests on natural durability. The latest inspection of specimens which have been under test for a maximum period of three years confirms that the following species are not durable under exposed conditions : beech, sycamore, London plane, hornbeam, elm, willow, ash, the sapwood of Scots, maritime and Corsican pines, silver fir and hemlock.

(*b*) Laboratory Tests of Natural Durability

A further number of laboratory tests upon the natural durability of home-grown and other Empire timbers has been carried out during the past year. Amongst timbers recently tested which have been found to possess a high natural resistance to the attack of decay-producing fungi are :

Mansonia : *Mansonia altissima* A. Chev.
East African camphor : *Ocotea usambarensis* Engl.
Opepe : *Sarcocephalus Diderichii* De Wild.
Waika chewstick : *Symphonia globulifera* L.f.

In a laboratory test of the durability of Californian redwood (*Sequoia sempervirens* Endl.) it was found that this timber is approximately equal to western red cedar in resistance to fungal decay.

Fundamental studies into the factors which influence the natural resistance of a timber to decay have been started. A method for rapidly determining whether water-soluble substances toxic to fungi are present in a timber has been devised and described in a note.[1] While it has already been shown by several workers that the natural durability of certain timbers such as western red cedar may be due to the presence of water-soluble extractives, in other

cases no actively toxic substance is present in the water extract from a durable wood. The toxicity of extracts from these timbers, soluble in other solvents, must therefore be examined. It is evident that the physical structure of the wood also affects its liability to decay.

The resistance to dry rot and other forms of decay of a further number of types of wall-board and insulating-board has been examined. Several of these have been submitted by the manufacturers, who sought information as to methods for rendering the materials rot proof.

[1] Ernest, E. C. A Test for the Presence of natural Preservative Substances in Wood. *Forestry*, 1936. (In the press.)

(c) Mine Timber Durability Tests

The inspection of treated and untreated mine timber undergoing service tests has been continued, and a progress report has been published giving the results of the tests after nearly five years' exposure.[1] It is inadvisable to draw definite conclusions at this stage of the tests, but it is possible to form an estimate of the value of the preservative treatments. The more expensive preservatives, namely, creosote, Wolman salts and sodium fluoride, are giving the best results at both pits, whereas sodium chloride even in strong concentrations is having the least preservative effect. Even this treatment, however, at a conservative estimate, doubles the life of the timber. The experiment is still in its early stages and future inspections will have increasing significance as regards results and the comparison of the different preservatives. The results so far obtained, however, amply demonstrate the suitability and economy of preservative treatment for mine timber under conditions favourable to decay.

[1] *Forest Products Research Records*—No. 3.

Preservation of Horticultural Boxes

Owing to the favourable conditions for decay the life of timber used for boxes and trays for the forcing of bulbs and other horticultural purposes is very short. There are a number of preservatives which will increase the life of such timber but undoubtedly some of these have an adverse effect on the plants. There are, however, some preservatives which would appear suitable and in order to determine whether they have any ill effect on the plants, a number of bulb boxes have been treated and these are being planted with bulbs and kept under observation at the Plant Pathological Laboratory of the Ministry of Agriculture. The main object is to ascertain the effect of the preservatives on the plants but data will also be obtained concerning the relative preservative efficiency of the different treatments. Similar tests are being carried out on untreated western red cedar, a very durable timber suitable for the construction of seed boxes.

Spruce Fence Posts

The resistance of spruce to impregnation with preservatives is very variable. It is generally considered to be high but instances have been reported where exceptionally good impregnation has been obtained even by the open tank process. To investigate the matter more closely, several consignments of spruce thinnings about 3–6 in. in diameter have been obtained from various localities in England and Scotland and they are being subjected to different methods of impregnation with creosote. The treatments have not yet been completed but there are indications that there is no significant difference in the amenability to treatment of timbers from the different localities. In a number of poles a brown stain has been observed, which appears to be connected with a condition in the wood which favours the absorption of creosote. This stain is associated with *Stereum sanguinolentum* and as the visual stain does not necessarily appear to limit the extent of the fungus infection it is possible that the condition of incipient decay produced by this fungus is the cause of the high absorption occasionally obtained with spruce.

Laboratory Tests on the Fire Resistance of Untreated Timber

The small scale testing of the natural fire resistance of timbers has been further developed. Work on a wide range of species has confirmed the suitability of the flame penetration test described in last year's report. Fire resistance, however, may be defined in several ways and there would appear to be no single test sufficiently comprehensive to include all the criteria. Accordingly, other methods in addition to that of flame penetration are being developed. One based on Schlyter's test is showing promise as an indication of the readiness with which the timber will ignite. Some difficulty has been experienced in comprehensively sampling a timber and a critical survey of the present methods of sampling is being made. Similarly, tentative standards for the classification of results have been arranged but are still on trial. Work has been commenced on the effects of fire retarding treatments. This may require apparatus different from that used on natural wood, but the aim will be to make the two comparable as far as possible.

Damage caused by Lyctus *Powder-post Beetles*

In spite of numerous requests received at the Laboratory from individual firms for advice and assistance in connection with damage caused by *Lyctus* beetles, satisfactory progress in the general application of control measures cannot be recorded, because the need for a united effort by all branches of the hardwood-using industries has apparently not been realised. The adoption of *Lyctus* control measures by a few individual firms is, however, a hopeful sign, for by their example it may yet be possible to demonstrate to the trade as a whole that with a little initial outlay

and trouble an organised campaign of *Lyctus* control would secure an extensive reduction of the damage from this cause in hardwoods.

Factors affecting Lyctus *Attack*

(a) The Food of *Lyctus* Larvæ

Much time has been spent in continuing the investigation upon the food relations of these insects. Earlier tests for the detection of protein enzymes in the larval gut were not sufficiently sensitive and a new method was therefore tried with satisfactory results. It is probable that starch, a substance soluble in water at 60° C., possibly soluble sugars, and protein are the three main constituents of wood which serve as food for *Lyctus* larvæ. This view is strengthened by the results of a series of experiments in which larvæ were fed on diets of different kinds of wood mixed with the substances mentioned above. Furthermore, in the course of this work, two small larvæ were reared to beetles on a mixture of starch, sucrose and peptone in the complete absence of wood.

It has been demonstrated that female beetles are able to determine the suitability of wood for larval development, and avoid laying their eggs in starch-free timber. Moreover, if, of two pieces of sapwood, one contains a little more starch than the other, although both have sufficient for normal larval development, the majority of eggs will be laid in the sample of greater starch content. A report on the research carried out on this subject during the past five years is now in the press[1] and an account of the work was given to Section D (Zoology) of the British Association for the Advancement of Science at the September meeting held at Norwich.

[1] Parkin, E. A. A Study of the Food Relations of the *Lyctus* Powder-post Beetles. *Ann. appl. Biol.*, 1936, **23** (2).

(b) Emergence and Flight of *Lyctus* Beetles

A start was made in preparing for analysis the figures obtained from the 1934 light trap experiments with *Lyctus* beetles, described in some detail in the last annual report. It was found, however, that in the experiments planned to determine the emergences and deaths of beetles in a small population, the number of emergences did not tally with the number of deaths. This could be accounted for only by assuming that beetles had been able to escape from the experimental cage. The experiment was therefore repeated in 1935, but the results were disappointing in view of the very small number of insects which emerged from what should have been heavily infested timber. This work is being continued.

The Control of Lyctus

(a) Methods of Starch Depletion

In continuation of the study of methods of rendering timber free from starch and consequently immune from *Lyctus* infestation,

four standing oak trees at Robertsbridge, Sussex, were placed at the disposal of the Laboratory through the courtesy of Messrs. John Stenning & Son, Ltd., Timber Merchants and Sawmillers, East Grinstead, Sussex. During July, two of these trees were girdled at the top of the trunk according to the method advocated by Mer[1] and the remaining two were similarly girdled at the top and bottom of the trunk. The amount of starch present in the trees was estimated from borings and samples of branchwood. In December, one tree of each type was felled, and numerous borings and samples of wood will be examined to ascertain the effect of the treatment. The two trees still standing will be felled for examination at the end of the summer, 1936.

[1] Mer, E. De divers moyens propres à préserver de l'attaque des insectes les écorces et les bois par résorption de leur réserve amylacée. *Mém. Soc. nat. Agric. Fr.*, 1903, **140**, 233–247.

(b) Kiln Sterilisation Treatment

The investigation, started in 1933 and continued in 1934, to determine the time required to kill larvæ in timber at kiln temperatures of 105°–125° F. and at a relative humidity of 60–80 per cent. has not yet been completed. One series of experiments only remains to be undertaken, but the work has been unavoidably delayed.

(*c*) Laboratory Tests of Wood Preservatives for the Prevention of *Lyctus* attack.

The results of tests with a number of water-soluble salts have shown that oak sapwood immersed for 30 seconds in a 5 per cent. aqueous solution of zinc chloride or sodium silicofluoride is not rendered immune from *Lyctus* attack. Similar experiments with 5 per cent. aqueous solutions of potassium chromate and borax, and with a 3 per cent. solution of sodium fluoride have given inconclusive results. This work is being repeated and the effect of a longer dipping treatment ascertained.

Mixtures of paraffin and creosote in proportions which will avoid discoloration of the wood have been recommended as a preservative suitable for use against *Lyctus*. In this connection tests have been undertaken at the Laboratory and the results, although not yet complete, indicate that a 30 seconds dipping treatment in a mixture of 1 part creosote and 9 parts paraffin will not prevent *Lyctus* attack, if treated oak sapwood is exposed to infestation two to three months after treatment.

Experiments on similar lines have also been carried out with orthodichlorbenzene, creosote derivatives, low temperature tar phenols, a 5 per cent. aqueous solution of formaldehyde and several proprietary preparations. These were applied to oak sapwood either by means of a single brush application or a dipping treatment of 10–30 seconds, and the samples were exposed to *Lyctus* beetles (i) two months and (ii) approximately one year after treatment.

Some of these substances failed to prevent egg laying, but in no case except in samples treated with formaldehyde, which proved completely ineffective, did larvæ survive for more than a few weeks, even when there was an interval of a year between treatment and exposure to attack.

The efficacy of treatment with such preservatives, as compared with the failure of the two water-soluble salts mentioned above, is probably due to better penetration, but for commercial use their greater cost is a serious disadvantage which in most cases would prohibit their adoption on a large scale for the prevention of *Lyctus* infestation.

(*d*) Application in Practice

At the request of the Royal Small Arms Factory, Enfield, a series of *Lyctus* infestation experiments was carried out with walnut from Enfield to ascertain experimentally the practicability of separating susceptible from immune stock by a simple iodine test. The results of this work showed that despite the apparent presence of sufficient starch in some of the samples, as revealed by the iodine test, these were unsuitable for larval development. A satisfactory explanation of this result has not been found, but it appears that the degree of susceptibility of walnut sapwood which has been submitted to a steaming treatment to modify the colour cannot be accurately determined by an iodine test for the presence of starch.

A schedule of work, consisting of a combination of regular inspections, segregation, kiln sterilisation and insecticide treatments of stock, for the prevention and control of *Lyctus* attack was drawn up for use, and has been adopted by the Royal Small Arms Factory.

The Death-watch Beetle (Xestobium rufovillosum)

In the last annual report an account was given of the occurrence and extent of present activity of the Death-watch beetle in old buildings throughout the country. The view then put forward, to the effect that the damage caused by this insect is not the result of increased activity and spread within recent years, is amply supported by the additional information that has been collected by the Laboratory during the past year. Further instances of attack have been recorded in old buildings but in the majority of cases it was evident that the insect had long been present, but only recently detected. One instance is, however, worthy of special note as illustrating the close relation that has been shown to exist between the presence of fungal decay in timber and its suitability for the development of the larvæ of the Death-watch beetle. In this case, the softwood block floor of a church, which had been severely attacked by a form of dry rot, was in parts almost completely eaten away by the larvæ of *Xestobium* in the comparatively

short period of twenty-five years. The vital importance of avoiding conditions favouring the development of dry rot or other forms of fungal decay in buildings in relation to subsequent Death-watch beetle attack cannot be too strongly emphasised.

In this connection, considerable time has been spent in initiating experiments designed to enquire more closely into the relationship believed to exist between the type and extent of fungal decay and the rate of development of the insect. This aspect of the Death-watch beetle investigation, which entails the co-operation of the Sections of Entomology, Mycology and Wood Chemistry, is of importance not only in relation to the prevention of this particular form of insect damage to timber but also with regard to the much wider subject of the inter-relationship of fungal and insect attack in timber in general and to the physiological problems of insect nutrition which are involved.

A further study of the effect of varying degrees of moisture content of decayed timber upon its susceptibility to *Xestobium* attack has also been started. Records of the moisture conditions in sound and attacked timber *in situ* in buildings have been taken.

Rearing of stocks of insects for future investigations on control has been continued and further information obtained upon the duration of the life-cycle under known conditions of temperature and humidity. The beetle has now been reared to the second generation in experiments carried out in the experimental house.

At the request of H.M. Office of Works advantage was taken of the presence of the scaffolding erected for the cleaning of the roof of Westminster Hall to examine the timbers for the presence of active Death-watch beetle attack. Although exit holes were present in parts of the roof, no living insects, beetles or larvæ were found during the inspection and it was evident that the insect was not obviously active in any of the timbers examined. The efficacy of the improved system of ventilation provided during the repairs of 1913–20 was demonstrated by a series of tests which the Laboratory made to determine the moisture conditions of the atmosphere and of the roof timbers. It is probable that this efficient ventilation has played an important part in checking the activity of the insect.

During inspections of buildings in which insecticide treatments have been carried out for the destruction of the Death-watch beetle, evidence has been forthcoming of the failure of a single and in some cases of two or more applications of insecticides to eradicate the insect from attacked timber.

Pin-hole Borer Damage to Empire Timbers

Collection of information upon the occurrence of Pin-hole borer damage to Empire and other timbers has been continued throughout the year and, when available, the insects responsible have been identified so far as possible at the British Museum (Natural History). Notes supplied by the Laboratory upon insects collected from

Mora excelsa in Trinidad were included in a publication[1] by the Forest Department, Trinidad, giving an account of the results obtained in preliminary investigations on methods of preventing Pin-hole borer and other insect attack in this timber.

The need for investigation of the Pin-hole borer problem formed the subject of a discussion, led by an officer of the Laboratory, at a meeting of the Fourth Imperial Entomological Conference[2] in London in September, 1935.

The results of the preliminary experiments, referred to in the last annual report, to determine the possibility of introducing preservatives into the sapwood of living trees with the object of rendering the timber unsuitable for insect attack have not been encouraging. In this work sodium arsenite in the form of 5 and 10 per cent. aqueous solutions or of a paste (sodium arsenite 50 parts, wood flour 50 parts, plus water) was applied to a girdle extending approximately $\frac{1}{2}$ in. into the outer sapwood of the elm trees available for experiment. Subsequently, the distribution of the arsenic was determined from examination of borings and samples of timber after felling and was found to be so irregular and in such minute quantities as to lead to the supposition that this method of treatment affords little promise as a means of preventing attack by wood-boring insects. Although it was not possible to carry out infestation experiments with Pin-hole borers, such work with *Lyctus* Powder-post beetles showed that the treatment did not prevent attack by these insects. As poison-girdling of trees by the introduction of sodium arsenite is now being used for the elimination of undesirable species in tropical forests, the value of this treatment for the prevention of Pin-hole borer attack in felled timber is worthy of further enquiry.

[1] Swabey, C. W. Notes on Insect Attack on Mora (*Mora excelsa* Benth.). *Leafl. For. Dep. Trin. Tob.*, 1935, No. **6.**

[2] Report of the Fourth Imperial Entomological Conference. London, Imperial Institute of Entomology, September, 1935.

Termites

During the year the Laboratory was asked by the British Wood Preserving Association to prepare a leaflet on methods of termite control. This request was discussed with the Director of the Imperial Institute of Entomology, when it was decided that sufficient information was not available to render such a publication possible. The urgent need for investigations on methods of prevention of termite attack is apparent from the requests received at the Laboratory for advice, and formed the subject of a discussion at the Imperial Entomological Conference. This Conference passed a resolution drawing attention to the very serious losses due to termites throughout the tropical and sub-tropical regions of the world and urging the need for collection of information on the species concerned, the damage caused and methods of control in practice.

Sirex *Wood-Wasps and Fungus Association*

Progress in this investigation has been hampered during the year by lack of suitably-infested wood. The supply obtained when the work was started proved to be heavily parasitised and has in consequence yielded very few specimens of *Sirex*. A watch is being kept, however, for infested wood, and when this is available, it is hoped to continue the investigation.

The Effect of Insecticides on Glues

The tests referred to on this subject in the report for 1934 have now been completed. It was found that the glue shear strength of joints and plywood made up with Scotch glue, casein cement, albumen cement and phenol resin glue as used commercially in the manufacture of furniture and plywood was not reduced by immersion in the insecticides tested, provided the material was given adequate time for drying after treatment. The insecticides concerned were orthodichlorbenzene and five proprietary preparations for the treatment of furniture or panelling attacked by wood-boring insects. The glue joints and plywood samples received a more drastic treatment than would be given in practice by repeated brush applications, and the results obtained indicate that none of the insecticides tested will reduce the strength of glue joints in furniture and other woodwork to which they are applied.

Fumigation

A comprehensive scheme of work upon the control of wood-boring insects by means of gaseous fumigants was drawn up and one of the biological aspects of the problem received attention during 1935, *viz.*, the determination of the concentration of hydrocyanic acid gas and the periods of exposure necessary to kill larvæ of *Lyctus* and *Anobium* removed from the wood. Subsequently, the work was extended to include *Lyctus* beetles. The experiments were carried out in the Entomology Department, Royal College of Science, South Kensington, in co-operation with an entomologist aided by a grant from Imperial Chemical Industries, Ltd. Curves showing the relationship between concentration and period of exposure necessary to kill all the larvæ at 20° C. and 25° C. have been obtained and the results of this part of the work are now being written up.

The physical aspect of the problem is being investigated by the National Physical Laboratory, where work is in progress upon the diffusion of gases in wood. It is hoped eventually to correlate the two lines of research so that it may be possible to calculate the concentration of gas in the atmosphere necessary to obtain a lethal concentration within pieces of infested wood. In the meantime, sufficient information is not yet available from the work so far completed to enable fumigation with hydrocyanic acid or

other toxic gases to be recommended as a certain means of controlling wood-boring insects.

Detection of Wood-boring Insects by Radio-valve Amplification

Improvements in the type of amplifier and "pick-up" used in preliminary experiments with insect-infested timber have been receiving the attention of the Radio Department of the National Physical Laboratory, with a view to the construction, now in hand, of a new amplifier and associated apparatus for use in a further series of experiments at Princes Risborough.

The Wharf-borer (Anoncodes (Nacerda) melanura *L.*)

Mention was made in the annual report for 1934 of the occurrence of the so-called Wharf-borer, *Anoncodes melanura*, in decayed timber in this country. In view of further records of the occurrence of this beetle and because of a request by the Forest Products Laboratories of Canada for information upon its economic status in this country, a brief account[1] of the records obtained by the Laboratory of the occurrence and habitat of this insect has been published.

[1] FISHER, R. C. The Habitat of *Anoncodes melanura* (Oedemeridæ). *Entom. mon. Mag.*, 1936, **72**, 41–42.

Physiological Studies of Fungi

The influence of the composition of the medium upon the fructification of Basidiomycetes in culture and the effect of variations in the carbohydrate-nitrogen ratio are being studied.

The effects of various nitrogenous substances upon the growth of wood-destroying fungi are being compared with a view to determining which are the most suitable sources for their growth and fructification in culture. The favourable effect of phosphates on the growth of these fungi has already been noted and a series of experiments is planned to determine the effect of increasing the phosphate content upon the rate of decay of wood.

In view of suggestions that the presence of calcium salts in wood may initiate decomposition, an extensive series of experiments has been carried out to determine the effect of treating wood with lime water before exposing it to the attack of decay-producing organisms. The results of these tests have indicated in every case that the presence of lime in a softwood tends to discourage the growth of the rot fungi and to reduce the amount of decay which takes place. In oak heartwood, on the other hand, the addition of lime appears to render the wood more liable to attack, possibly by its action in inactivating the tannin present. No direct decomposition of the wood by the action of lime was observed. A paper summarising these results is to be prepared for publication.

Further experiments have been carried out to determine whether slight decay produced by a heart rot fungus renders wood more liable to dry rot. Indications have been found that slight initial decay produced by *Trametes pini* increases the subsequent rate of attack by *Merulius lacrymans*, but further work is required to establish this definitely.

A further number of tests has been carried out upon the relative liability of clear and of blue-stained wood to decay by dry rot fungi. Somewhat contradictory results have so far been obtained and no significant difference has yet been established.

Decay of Oak Wood

The principal rots of English oak have been described in a monograph which also summarises most of the important previous work that has been carried out on this subject. In addition to descriptions of the various rots, details of the fungi in culture and the microscopic characters of the mycelium have been recorded. Keys have been drawn up for the identification of the different rots from their appearance and from the growth of the fungi in culture. This volume, which it is intended shall be the first of a series dealing with the principal rots of the most important timber species or groups of species, is now in the press.[1]

Further work on *Fistulina hepatica*, the fungus responsible for 'brown' oak, has been carried out. It has been found that a similar type of coloration in Spanish chestnut can be caused by this fungus—though in this species the brown colour is not usually so uniform or so widely spread in the tree. Cultural studies of the nutrition of this fungus indicate that the growth of the fungus is stimulated by the presence of tannin, from which it is probably able to obtain part at least of its carbohydrate supply. An account of this work is now in the press.[2]

In order to determine how quickly *F. hepatica* can spread in a living tree, a number of inoculations have been made into living branches of a small oak tree in Bagley Wood, Oxford. Branches will be removed at intervals and the rate of spread of the fungus determined.

[1] CARTWRIGHT, K. ST. G., and FINDLAY, W. P. K. The Principal Rots of English Oak. London, H.M. Stationery Office. (In the press.)

[2] CARTWRIGHT, K. ST. G. A Re-Investigation of the Cause of 'Brown' Oak. *Trans. Brit. mycol. Soc.* (In the press.)

Dry Rot Investigations in the Experimental House

The continuation of exceptionally dry conditions during the first half of 1935 prevented the development of dry rot in the badly constructed room. Since the effects of the various faults in construction upon the development of a dry rot outbreak have now been amply demonstrated, it has been decided to moisten the floor in this room artificially in order to encourage an active growth of dry

rot and thereby provide material for experiments on the sterilisation *in situ* of infected members.

The new solid floor consisting of boards nailed to pressure-creosoted fillets embedded in the concrete, which is covered with a layer of bitumen about $\frac{1}{8}$ in. thick so that nowhere do the boards come into actual contact with the concrete or the fillets, has been artificially infected with *Merulius* and *Coniophora*, but no trace of decay is yet apparent. This type of floor will probably prove to be quite satisfactory except where considerable amounts of surface water are allowed to penetrate, as, for instance, where previous linoleum is frequently washed.

Fungal Staining of Timber

In view of the increasing number of enquiries now received at this Laboratory concerning staining in, and mould on, timber, it has been decided to extend the research work with a view to finding improved control methods. The matter will become one of still greater importance to home-grown timber merchants and users when timber from the plantations of softwoods established in recent years is ready for conversion.

A number of laboratory tests on antiseptics for use in dipping treatments have been carried out in addition to the field experiments. Very satisfactory and rapid results were obtained in an experiment carried out in a model kiln in which the temperature and humidity were maintained at the optimum for the growth of the staining organisms, and it is proposed to carry out further experiments in this way.

An article describing the results of the field experiment alluded to in the last report has been published in a trade journal.[1] In this experiment the conditions of test were severe and it was found that under such circumstances weak antiseptics such as sodium carbonate (5 per cent.) and sodium bicarbonate (5 per cent.) had very little effect in checking the development of stain and mould. A fair measure of control was obtained by the use of certain proprietary antiseptics but the results showed that even where an antiseptic dip is used, the ordinary precautions of stacking the timber so that it can dry out rapidly must not be neglected.

Another field experiment has been started in which 800 cubic feet of Scots pine were converted into $1\frac{1}{4}$-in. boards and dipped in various antiseptics immediately after sawing. These have been stacked in two piles—one with $\frac{1}{2}$-inch piling sticks and the other with 1-inch piling sticks, and they will be taken down and examined as soon as the timber is seasoned.

The problem of preventing sycamore boards from becoming stained during drying has received attention, and an experimental pile of sycamore planks was erected in January. Some of the planks were dipped in an antiseptic bath immediately after sawing,

and others were exposed to short steaming treatments. The results of this experiment indicate that the development of internal stain in sycamore is probably due in most cases to a chemical change in the contents of cells and not to the growth of any staining organisms in the wood. These changes appear to take place wherever the timber is not freely exposed to the air. A further experiment is projected.

A leaflet, describing how stains due to fungi may be recognised and distinguished from those due to incipient decay or to chemical causes and indicating possible control measures, has been prepared and is now in the press.[2]

[1] FINDLAY, W. P. K. The Prevention of Blue Stain and Mould on Timber by Chemical Dips. *Timb. News Sawm. Chron.*, 1936, No. **2022**, 14, 17.

[2] *Forest Products Research Leaflet*—No. 12. Sap Stain in Timber—its Cause, Recognition and Prevention. (In the press.)

Fungal Staining of Paint Films

In co-operation with the Building Research Station, further tests have been made on the susceptibility of white lead linseed oil paints containing various antiseptics to develop mould growth under damp conditions. A number of proprietary anti-fungus paints have also been tested. So far, no paint has been found which is absolutely immune from all types of mould growth, though some of them are very much more resistant than ordinary white lead paint.

The Effect of Chemical Reagents on Wood

(a) The Lignin Determination in Wood Analysis

The principal immediate objective in the study of the lignin determination has now been reached. After an extensive series of experiments and a critical review of the results of other workers in the field of wood chemistry a revised method of estimating lignin by means of sulphuric acid has been worked out. A publication embodying the details of this method is in preparation. It cannot be over-emphasised that the "lignin" about which so much chemical discussion has centred may, despite recent analytical refinements, still be as much a product of the method of isolation as of the tree itself. The work just completed is none the less justified since for some time to come a standard routine method of estimating lignin in wood will find many practical applications. From the fundamental standpoint much still remains to be done before the process of lignification in the living tree is clearly understood.

(b) The Action of Aqueous Ammonia on Wood Substance

Although ammonia is one of the commonest chemical reagents there is little available information concerning its action on wood substance. Its use in the "fuming" of wood is of course well

known, the general opinion being that the colour change is a result of the action of the reagent on tannin in the presence of oxygen. In the course of a study, which is still in progress, it has been found that in general the solvent action of aqueous ammonia on wood is mainly confined to the minor constituents. There is no proportionality between the amount of material dissolved and the concentration of the reagent. Even with concentrations up to 35 per cent. NH_3 at room temperature, cellulose and its associated furfural-yielding material are apparently unaffected, but there are indications that the furfural-yielding complexes not associated with the cellulose, as well as lignin, are decomposed to a slight extent.

The Relationship between the Starch and Hemicelluloses of Oak Sapwood

In the previous report[1] it was mentioned that the starch recently isolated from oak sapwood has been found to have certain constitutional factors in common with hemicellulose A.[2] A preliminary account of the properties and composition of oak sapwood starch has now been published[3] and during the current year two other polysaccharides have been isolated from the same wood which bear an even closer resemblance to hemicellulose A than starch, in that they have higher contents of uronic and aldobionic anhydride and anhydro-xylose residues. A note concerning the first of these has been published[4] and the hypothesis is advanced that certain of the so-called hemicelluloses of oak wood are derived from starch in a series of steps involving the oxidation of primary alcoholic groups and the subsequent formation of anhydro-xylose residues by decarboxylation. It is suggested that a more suitable term for hemicellulose derived in this way would be "amylouronide."

[1] Report of the Forest Products Research Board for the Year 1934 (pp. 32–42). London, H.M. Stationery Office, 1935.
[2] O'Dwyer, M. H. *Biochem. J.*, 1934, **28**, 2116–2124.
[3] Campbell, W. G. *Biochem. J.*, 1935, **29**, 1068–1080.
[4] Campbell, W. G. *Nature*, 1935, **136**, 299.

Hemicellulose A from Oak Sapwood

One of the chief points of resemblance between hemicellulose A and starch is the blue colour which both substances give with iodine. This has led to the suggestion (O'Dwyer, M.H., *loc. cit.*) that hemicellulose A may contain a small percentage of anhydroglucose residues. It has been found that the enzyme takadiastase, which under optimum conditions effects almost complete hydrolysis of the common starches, produces a partial hydrolysis to reducing sugar of hemicellulose A. Experimental evidence suggests that the reducing sugar in question is glucose, that it represents 5–10 per cent. of the original hemicellulose and that when it is split off an aldehydic linkage in the parent hemicellulose is severed. This would appear to confirm the suggestion that the molecule of

hemicellulose A contains a small proportion of anhydro-glucose residues, and also to support the hypothesis mentioned above concerning the origin of the acid polysaccharide.

Hemicellulose B from Oak Sap-wood

After the precipitation of hemicellulose A from the alkaline extract of wood by means of acetic acid a further precipitate is obtained from the supernatent liquor on the addition of alcohol. This second substance has been termed hemicellulose B[1]. A preliminary investigation of the composition and properties of hemicellulose B from the wood of English oak has shown that this is also an acid polysaccharide. The sapwood product is much less stable than the heartwood product and while the former gives a reddish violet coloration with iodine the latter gives no colour reaction with this reagent. It would appear that the transition from sapwood to heartwood is accompanied by changes in the constitution of hemicellulose B as well as hemicellulose A[2].

[1] O'Dwyer, M. H. *Biochem. J.*, 1926, **20**, 656–664.
[2] Report of the Forest Products Research Board for the year 1934.

Effects of Pruning on the Quality of Timber

Of the defects which influence the quality and grade of timber, knots are probably the most serious, and investigation of the practical and economic possibility of minimising knot development in the growing tree by pruning is of the first importance to foresters and timber growers. The Laboratory is studying this problem in collaboration with the Forestry Commission, the latter dealing with the silvicultural and costing aspects in the field, and the Laboratory with the results of pruning, as evidenced by the rate and completeness of occlusion and the increase in percentage of higher grade material.

During the year, examination of pruned logs was continued and valuable data collected as to the manner of occlusion in various species pruned under different conditions. The progress of this side of the investigation is necessarily slow, owing to the difficulty in obtaining suitable, pruned trees, but enquiries are being made throughout the country as to sources of pruned timber and it is expected that further material will shortly be available.

Statistical studies of the improvement in grade that may be expected as a result of applying different pruning schedules were continued with encouraging results. More definite information is now available as to when pruning should be carried out to achieve the best results.

Turnery Survey

As part of the general programme of utilization studies, a number of firms engaging wholly or partly in turnery were visited. A summary of information obtained as to the timbers used, sources

of supply and other particulars, is being forwarded to the Forestry Commission for inclusion in the Survey of the Home Timber Industries.

Certain native species used by or likely to be of service in the turnery industry have been brought into the Laboratory for turning tests in 1936.

Grading (*Grading Rules for Empire Hardwoods*)

The results of the grading studies carried out on consignments of Empire timber supplied for investigation and trials have proved of considerable value and interest to the producer by providing information on the relative yield and value of the potential marketable supply of the species dealt with.

The Hardwood Grading Rules formulated by the Imperial Institute Advisory Committee on Timber have been applied to a number of consignments of Empire timbers received during the year.

Co-operative Work and Investigations

(a) Taint and Flavouring Effect of Wood on Cider

The Laboratory has co-operated with the Research Station of the Department of Agriculture and Horticulture of the University of Bristol at Long Ashton in an attempt to find new timbers for the construction of wooden containers for use in the cider-making industry. Specimens of eleven timbers have been supplied for immersion tests in cider to determine what effect, if any, these timbers have on its flavour.

(b) Exudation of Gum from Cigar-box Cedar

Observations on the exudation of gum from cigar-box cedar with a view to the possibility of developing some method of prevention are now being made on specimens of cedar supplied by two firms interested in this problem.

(c) Application of Paints to Softwoods

In co-operation with the Paint Research Station, Teddington, and the Building Research Station, Watford, arrangements are being made for the selection and preparation of timber to be used in trials to be carried out at the Paint Research Station.

Tests on the application of a resin-benzene solution, with a view to preventing raising of the grain in Douglas fir, were carried out at the request of the British Columbia Lumber Commissioner. The results indicated that this method of treating Douglas fir does not promise to be successful.

Veneers, Plywood and Adhesives for Wood

The increasing use of laminated wood and the attendant defects and failures have resulted in a considerable increase in the number of enquiries connected with this subject. The growing importance

of laminated wood products is making apparent the desirability of installing at the Laboratory the necessary plant for carrying out trials and investigations on the manufacture of veneers, laminated wood products and adhesives.

Charcoal and the Utilisation of Wood Waste

The number of enquiries received from both home and oversea sources has been more than doubled during the year under review. The use of portable charcoal kilns has aroused considerable interest, particularly for use in conjunction with the manufacture of charcoal for producer-gas plants. Co-operation with manufacturers of portable kilns is being maintained.

Cinematography and Photography

The most notable event in the year's work of the Photography Section has been the acquisition of first-class apparatus for 16 mm. cinematograph work. Three films have already been completed and three more are in course of production.

During the year 1,462 negatives, 185 photomicrographs, 7,307 photo-prints, 237 lantern slides, 3,441 opalographs and 2,545 blue prints have been made.

In connection with cinematograph work and lectures, the Road Research Station, Fuel Research Station, Glasgow, Gloucester and London have been visited.

Enlargements, prints and lantern slides were prepared for the Summer School and played an important part in the lectures to the students.

Publications and Records

During the year, work on the index of trade and vernacular names of timbers was concentrated mainly upon timbers of the Empire, though a beginning was also made on the referencing of names of timbers of foreign countries and their colonies. As the work involved in the preparation of the index is of considerable magnitude, it is difficult to estimate actual progress other than by the increase in the number of names referenced. These totalled 31,560 at the end of the year, including 22,945 vernacular names and 8,615 botanical ones. Progress in future years will of necessity be considerably slower, owing to the fact that the officer engaged in indexing has been transferred to the Section of Wood Structure since the first half of November, and in consequence is now only able to devote a relatively small proportion of his time to the work.

Five numbers of the new series of publications, entitled the Forest Products Research Records, were issued during the year, and seven others are in the press or in preparation. Many of these have received good notices in the press and appreciation of this method of presenting the results of investigations has been shown in other spheres.

The second edition of the booklet on " The Uses of Home-grown Timbers " is out of print, and owing to the accumulation of considerable additional information resulting from work which has been completed since its issue, it has been deemed expedient to abandon the idea of a third edition and to publish the new data together with some of the matter from the old publication in another form.

Revised editions of three of the Laboratory's leaflets were issued during the year, as well as two new leaflets and twenty-three reports on investigations under various projects.

It is edifying to note that there has been an increase in the number of requests for reprints of the various Laboratory papers that are published each year in the scientific and technical press.

III. ADVISORY WORK

Wood Structure

The steady increase in the volume of advisory work is indicated by the fact that the annual number of enquiries dealt with has more than doubled in the last five years. As usual, many requests have been received for the identification of timbers with a view to obtaining supplies. Other enquirers have sought the opinion of the Laboratory on the quality of wood used in manufactured articles. Of a more unusual nature have been enquiries from prospective importers as to the kinds of timber found in Persia and Venezuela, while a firm of engineers which was proposing to equip sawmills in Mexico and Brazil, respectively, was supplied with particulars of the timbers of the countries concerned. These cases are mentioned as examples of the occasional demand for information which would not generally be considered as having close connection with British industrial interests.

Seasoning

There was a further increase of over 50 per cent. in the number of enquiries pertaining to seasoning during the year under review. Of these, over 85 per cent. were from trade sources asking for advice and assistance in practical problems connected with kilns, drying, steam-bending and the moisture relations of timber.

A seasoning questionnaire sent to 1,500 firms asking for details of their drying procedure, difficulties in seasoning, etc., elicited over 600 replies and served as a useful guide to the drying problems with which industry is faced.

With a view to assisting those who prefer to erect their own timber-drying kilns a pamphlet[1] on the overhead internal fan kiln has been prepared and issued to many enquirers.

[1] Bateson, R. G. Timber Drying Kilns—the Overhead Internal Fan Kiln. *Forest Products Research Leaflet*, No. 10.

Timber Mechanics

A considerable volume of enquiries has been handled during the year and a number of investigations have been made at the request of outside bodies. Instances of the latter are :—

1. Tests on behalf of a firm of timber merchants to determine the holding property of a range of types and sizes of spikes and screws in hardwood sleepers.

2. Tests on behalf of a manufacturer to determine the relative strengths of a number of extension ladders of different construction.

3. Tests on behalf of a firm of timber merchants to determine the screw-holding property of oak flooring with reference to the adequacy of the screws holding down the seating in a cinema.

Woodworking

Many enquiries have been received in connection with sawmilling and woodworking matters. Information has been given on the working qualities of a number of timbers and their suitability for particular purposes, on methods of overcoming difficulties in the sawing and machining of some of the more refractory species, on suitable sawmilling equipment, machines and their lay-out for a joinery factory, for box making and other purposes, on machines and their operation in bobbin manufacture, and various other problems.

Entomology

The services of the Entomology Section in giving advice and assistance with regard to insect damage to timber have again been in constant demand. The number of enquiries received by letter during 1935 amounted to 541, whilst, in addition, 13 inspections of buildings have been carried out and recommendations made on the treatment of insect-infested timber. Apart from enquiries dealing with insects causing damage to timber in this country, advice has been sought by Government Departments and others overseas with regard to their timber-insect problems, among which methods of prevention and control of Pin-hole borers and termites are of particular importance.

During the year, attention was again called to the occurrence of the Longhorn beetle, *Hylotrupes bajulus*,[1] when two further instances of damage by this insect in London and York were brought to the notice of the Laboratory.

[1] PARKIN, E. A. The House Longhorn Beetle. A New Pest of Softwood Structural Timbers. *J. R. Inst. Brit. Archit.*, 1935, **42**, 1148.

Mycology

A large number of enquiries have been dealt with by the Mycology Section during the past year. While the majority of these have referred to dry rot and other types of decay in buildings, the number of enquiries concerning the prevention of stain and mould on timber has again increased. The testing of wood preservatives on behalf of manufacturers and tests of the resistance of various building materials to dry rot have occupied an increasing amount of the Section's time.

Further instances of decay in the lining of refrigerated ships have been observed and the prevention of rot in small craft such as yachts and power boats, especially in those used in the tropics, has been the subject of several enquiries. An article has been written for publication in one of the shipping journals to draw attention to the possiblity of preventing this type of damage by the use of wood preservatives.

Representation on Outside Committees

The Laboratory is represented on the following Committees :

Standing Committee on Empire Forestry—
(*Representative :* Mr. W. A. Robertson).

Empire Forestry Association—
Governing Council
(*Representative :* Mr. W. A. Robertson).

Trade Names Committee
(*Representatives :* Mr. W. A. Robertson and Mr. B. J. Rendle).

Publications Committee
(*Representatives :* Mr. W. A. Robertson and Mr. H. A. Cox).

British Standards Institution—
Technical Committee AC/2, Timber (Aircraft)
(*Representative :* Mr. C. J. Chaplin).

Technical Committee AC/3, Plywood
(*Representative :* Mr. C. J. Chaplin).

Technical Committee B/10, Standard Definitions and Tests for Fire Resistance and Incombustibility
(*Representative :* Mr. N. A. Richardson).

Technical Committee B/14, Joinery
(*Representative :* Mr. C. J. Chaplin).

Technical Committee B/19, Unit Weights of Building Materials
(*Representative :* Mr. S. T. C. Stillwell).

Technical Committee B/24 on Timber
(*Representative :* Mr. C. J. Chaplin).

Sub-Committee B/11/1 (Drafting), Commercial Plywoods
(*Representative :* Mr. H. E. Kinns).

Sub-Committee B/24/1, on Softwood Grading
(*Representative :* Mr. C. J. Chaplin).

Sub-Committee B/24/2, Methods of Testing Small Clear Specimens of Timber
(*Representative :* Mr. C. J. Chaplin).

Sub-Committee C/10/2, Fungal Restraint by Antiseptic Substances
(*Representative :* Mr. K. St. G. Cartwright).

Panel C/10/2.1, Tests on Toxicity of Wood Preservatives
(*Representative :* Mr. K. St. G. Cartwright).

Technical Committee C/15 on Glues
(*Representative :* Miss C. B. Pettifor).

Sub-Committee EL/17/2 on Poles, Brackets, etc.
(*Representative :* Mr. J. Latham).

British Wood Preserving Association—
(*Member of Council :* Mr. W. A. Robertson).

Technical Committee
(*Representatives :* Mr. W. P. K. Findlay and Dr. R. C. Fisher).

National Home-grown Timber Council—
(*Member of the Council :* Mr. W. A. Robertson).

Timber Development Association—
(*Member of Council :* Mr. H. A. Cox).

Public Relations Committee
(*Representative :* Mr. H. A. Cox).

Forestry Commission—
Advisory Committee on Forestry Research
(*Representative :* Mr. W. A. Robertson).

Home-grown Timbers Committee
(*Representative :* Mr. W. A. Robertson).

City of London College—
Timber Trades Advisory Committee
(*Representative :* Mr. W. A. Robertson).

City and Guilds of London Institute—
Advisory Committee on Woodcutting Machinists' Work
(*Representative :* Mr. P. Harris).

IV. WORK FOR THE EMPIRE OVERSEAS

Particulars of work carried out for the units of Empire overseas are found in Appendix II, the Second Annual Report of the Standing Conference on Timber Utilisation.

APPENDIX I

LIST OF SCIENTIFIC AND TECHNICAL STAFF

Director of Forest Products Research : W. A. Robertson.
Assistant to Director : S. T. C. Stillwell, B.Sc.
Administration Officer : A. R. H. Cox, B.Sc.
Scientific Officer : H. A. Cox, M.A., Dip.For., Dip.Tim.Tech.
Scientific Field Assistant : A. N. David.
Publications and Records Officer : C. J. N. McCracken, B.A., Dip.For.
Assistant, II (Photographer) : W. R. Hutchins.

Section of Wood Structure

Officer in Charge : B. J. Rendle, B.Sc., A.R.C.S.
Scientific Officer : S. H. Clarke, M.Sc.
Junior Scientific Officer : E. W. J. Phillips, B.Sc., A.R.C.S.
Assistant, III : C. L. Stocker, B.A., Dip.For.

Section of Timber Physics

Officer in Charge : W. W. Barkas, M.Sc.
Scientific Officer : E. D. van Rest, B.A., B.Sc.

Section of Seasoning

Officer in Charge : R. G. Bateson, B.A.
Scientific Officers : R. A. G. Knight, B.Sc.(Eng.), A.M.I.Mech.E., W. C. Stevens, M.A., A.M.I.Mech.E.
Assistants, III : R. E. Hodge, D. D. Johnston, R. J. Newall, N. Turner, G. H. Pratt, A. R. Dean.

Section of Timber Mechanics

Officer in Charge : C. J. Chaplin, M.Sc., M.E.I.C., M.I.Mech.E.
Scientific Officers : J. Latham, B.Sc., Miss C. B. Pettifor, B.Sc., F. H. Armstrong, M.Sc., A.M.I.Mech.E., E. H. Nevard, B.Sc.(Eng.).
Junior Scientific Officer : H. Q. Golder, B.Eng.
Assistants, III : R. H. W. Burkett, B.Sc., A. J. Foord.

Section of Wood Preservation

Officer in Charge : J. Bryan, M.Eng., A.M.I.C.E.
Scientific Officer : N. A. Richardson, B.Sc., A.I.C.
Assistants, III : L. S. Doman, D. N. Smith, R. J. Griffiths.

Section of Entomology

Officer in Charge : R. C. Fisher, B.Sc., Ph.D.
Scientific Officers : F. R. Cann, D.I.C., E. A. Parkin, M.Sc., D.I.C.
Assistant, III : E. C. Harris.

Section of Mycology

Officer in Charge : K. St. G. Cartwright, M.A., D.I.C., F.L.S.
Scientific Officer : W. P. K. Findlay, M.Sc., A.R.C.S., D.I.C., A.I.C.T.A.
Assistants, III : E. C. Badcock, Miss E. C. M. Ernest, B.Sc., Ph.D., D.I.C.

Section of Wood Chemistry

Officer in Charge : W. G. Campbell, B.Sc., M.S.
Scientific Officers : Miss M. H. O'Dwyer, B.Sc., Ph.D., D.I.C., Mrs. K. F. Bamford, B.Sc., Ph.D., A.I.C.
Junior Scientific Officer : S. A. Bryant, B.A.
Assistant, III : D. F. Packman.

Section of Utilisation

Scientific Officer : P. Harris, B.Sc.
Assistant, I : H. E. Kinns.
Assistant, III : G. H. Donald, B.A.

APPENDIX II

STANDING CONFERENCE ON TIMBER UTILIZATION

*REPORT OF THE STANDING CONFERENCE FOR THE YEAR ENDED 31st DECEMBER, 1935

The value of the opportunities offered by the meetings of the Standing Conference for the free discussion of questions concerning the development of the forest resources of the Empire, the investigation of the properties of new or little known timbers and the promotion of trade in timber between the various units of the Empire, has been more fully appreciated during the year under review. In consequence, the Conference realised the expediency of amending the Rules and Standing Orders so as to allow of the expansion of its constitution. (*See* page 66.)

Meetings and Business Done

Two meetings of the Standing Conference were held during the year, the first at 16 Old Queen Street, Westminster, on 27th February, and the second at the Forest Products Research Laboratory, Princes Risborough, on 10th September. On both occasions the Chair was occupied by Sir John Stirling Maxwell, Bart., K.T. The attendance at the second meeting was affected by the absence of several members who had been appointed delegates by one or other of the co-operating bodies to the Fourth British Empire Forestry Conference, which was held in South Africa in September and October.

At the first of the two meetings the Draft Report of the Standing Conference for the year 1934 was considered, approved and adopted. The Conference also received a report from the Department of Scientific and Industrial Research, bearing on the appointment of a representative to the Conference by the High Commissioner for the Union of South Africa, on the work in progress at the Forest Products Research Laboratory for various oversea units of the Empire, and on contact with regions within the Empire engaging in timber production. A detailed report on the progress of investigations of Empire timbers was considered and, after discussion, was received.

A statement concerning further applications for tests of Empire timbers was submitted by the Department, and the Conference recommended that tests of the natural durability of three timbers, on behalf of the Malay Forest Research Institute, should be undertaken, but that the application for preliminary tests on a fourth species should not be accepted on the grounds that the timber in question did not appear to possess the properties necessary to secure a favourable reception in the markets of the Empire, and that, in any case, since facilities existed for testing the timber in Malaya, the application should have been submitted in the first place through the usual official channels to the Forest Research Institute at Kepong. Changes in the method of procedure to be adopted in view of the establishment by the Colonial Office of the Colonial Forest Resources Development Department were explained.

The question of the priority to be accorded by the Colonial Office to certain colonies in arranging the programme of future visits directed towards the further exploitation of the forest resources and the better organisation of the means of production was discussed and recommendations were made to the Colonial Office.

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* Being a report prepared by the Conference under Standing Order No. 9, which provides for the submission annually to the co-operating bodies of an Annual Report of the proceedings of the Conference. (*See* page 68.)

At the second meeting, a report was presented by the Department in which it was stated that two representatives to the Conference had been appointed by the High Commissioner for New Zealand, under No. 2 of the Rules and Standing Orders, and that an invitation had been sent to the High Commissioner for Southern Rhodesia to appoint a representative under the same rule. It was also stated that two representatives nominated by the Secretary of State for the Colonies, had been appointed by the Department to represent the Colonial Forest Resources Development Department.

The Conference then considered a memorandum on a proposal of the High Commissioner for the Commonwealth of Australia that the Constitution of the Standing Conference should be enlarged to include representation of any Dominion which desired to appoint to its membership. The proposal received strong support from the representatives of the Colonial Office on the grounds that the Conference offered opportunities for discussion of matters of mutual concern to both Dominions and Colonies. A resolution providing for amendment of Nos. 1 and 2 of the Rules and Standing Orders so as to permit of enlargement of the constitution in accordance with the proposal was moved by the representative of the Union of South Africa and carried unanimously. A further resolution amending No. 6 of the Rules and Standing Orders so that only two regular meetings need be held annually was carried unanimously.

The Department presented a report on the progress made in the investigation of the properties of various Empire timbers at the Forest Products Research Laboratory in the period which had elapsed since the previous meeting. Certain questions concerning the investigations were answered by the Director of Forest Products Research.

Applications for preliminary investigations of the properties of six Nigerian timbers were considered and the Conference recommended that the tests should be undertaken, but that they should be limited to those which on further consideration were held to be necessary.

A statement was made by a representative of the Colonial Office concerning the action which it is proposed to take in furtherance of the policy to establish closer contact with the regions of production in various colonies.

JOHN STIRLING MAXWELL,
Chairman.

REPORT BY THE DEPARTMENT TO THE CONFERENCE ON THE INVESTIGATION OF EMPIRE TIMBERS FOR THE YEAR ENDED 31ST DECEMBER, 1935

A full programme of investigations of the properties of Empire timbers has been carried out at the Department's Forest Products Research Laboratory during the year. Most of the work has been connected with timbers from one or other of the Colonies, but it is worthy of remark that the Dominions of New Zealand and the Union of South Africa and the self-governing colony Southern Rhodesia have made use of the facilities offered by the Department through its Forest Products Research Laboratory. Since the establishment of the Colonial Forest Resources Development Department at the beginning of April, the marketing work in connection with Colonial timbers which had been undertaken as a temporary expedient by the Laboratory has ceased. The Colonial Forest Resources Development Department is now responsible for organising service trials of Colonial timbers outside the Laboratory, which, however, still supplies scientific or technical information concerning Empire timbers in response to enquiries.

Details of the various investigations which have been carried on during 1935 are set forth on page 4 under the heading " Progress of Investigations." From the number of enquiries for information concerning the properties of Empire timbers, it may be assumed that interest in them continues to grow.

Applications for Tests of Colonial Timbers

A list of the applications for further investigations of Colonial timbers, received during 1935, and considered by the Standing Conference is given below.

Preliminary Investigations :

(1) *Guarea cedrata* (A. Chev.) Pellegrin.

(2) *Terminalia ivorensis* A. Chev.,—Idigbo or Black Afara.

(3) *Cistanthera papaverifera* A. Chev.,—Otutu.

(4) *Gossweilerodendron balsamiferum* Harms.,—Agba.

at the request of the Forest Department, Nigeria. (It was suggested that—

(5) *Guarea Thompsonii* Sprague & Hutch. and

(6) *Terminalia superba* Engl. et Diels.

should be added to the above as in the case of the former (No. 5) it frequently occurs along with No. 1, and in the case of the latter it has been used in the Cameroons for the manufacture of plywood, and might also prove suitable for sawn timber. The Forest Department in Nigeria accepted the suggestion, which emanated from the Colonial Forest Resources Development Department.)

(7) *Calophyllum Wallichiana* Planch. et Triana, from Malaya.

at the request of a firm in the United Kingdom.

The Standing Conference recommended the acceptance of the first six of the above applications, and the rejection of No. 7 on the ground that the investigation, if necessary, could be undertaken at the Forest Research Institute in Malaya, and therefore application should have been made there.

Special Investigations :

For tests of the working qualities of :

(1) *Dipterocarpus Baudii* Korth—Keruing.

(2) *Shorea lævis* Ridl.—Kumus.

(3) *Intsia Bakeri* Prain—Merbau.

(4) *Shorea pauciflora* King—Nemesu.

(5) *Sloetia sideroxylon* Teysm. et Binn.—Tempenis.

at the request of the Forest Research Institute, Malaya.

(6) *Piptadenia africana* Hook.f.—Ekhimi.

(7) *Distemonanthus Benthamianus* Baill.—Ayanran.

at the request of the Forest Department, Nigeria. The above applications were accepted.

An application was received from the High Commissioner for the Union of South Africa for arrangements to be made for officers of the Laboratory to inspect a further consignment of oranges shipped in boxes made from wood grown in South Africa and to report on the condition of the boxes on arrival. The work was undertaken on a fee basis and a report was issued.

The New Zealand Government, through its High Commissioner, sought the assistance of the Laboratory in testing butter boxes of different types in its newly installed box-testing plant. This work was also undertaken on a fee basis.

Progress of the Investigations

A. *Investigations Completed*

During the year covered by this report, the following investigations have been completed and reports have been issued.

Major Scale Investigations

1. Mora : *Mora excelsa* Benth., from Trinidad

This investigation showed the timber to be somewhat refractory and on this account it would be decidedly difficult to market it in this country at an economic price, except possibly for flooring or some other special purpose. The timber might be used in Trinidad, however, partly to replace the imported timber now largely used. The report was issued in June.

2. Banak : *Virola merendonis* Pittier, from British Honduras

The report on the major scale tests of the properties of Banak was completed and issued in August. A trial consignment was shipped to this country, but for some reason, which may have been connected with insufficient or improper seasoning prior to shipment, the timber, on being resawn, developed extensive surface checks. Reports on service trials carried out by one private firm and one railway company have been received since the Laboratory's report was issued. In both cases the timber had been under trial to determine its suitability for use in making battery separators. The reports showed that Banak was unsuitable for the manufacture of the thin separators for car batteries as it failed mechanically in the 1·5 mm. thickness. For the railway batteries, however, in which separators 6 mm. thick are used, the wood proved quite satisfactory.

Limited Major Scale Investigation

3. East African Camphor : *Ocotea usambarensis* Engl.

In May the investigation of the properties of Kenya, East African, or Ibean camphor was completed and a report was issued. The wood kiln-seasoned fairly easily with less distortion than was anticipated from the report on kiln-seasoning experiments carried out in the country of origin. It worked with little difficulty, although there was some tendency for the grain to " pick up " in quartered stock. The strength properties proved to be similar to those of oak, although the wood was lighter and somewhat softer than oak. Apart from the stripe, which was a feature of quarter-sawn material, there was a lack of character, however. The timber, therefore, falls into the category of good class joinery woods, and as there are already in this class a considerable number of timbers available at competitive prices, there is not likely to be an appreciable market for the Kenya camphor in this country. Nevertheless, there are further uses to which it could be applied in East Africa.

Preliminary Investigation

4. Yemeri : *Vochysia hondurensis* Sprague, from British Honduras.

The preliminary investigation of the properties of Yemeri was completed in July, and a report was issued immediately. The wood was found to lack the necessary characters or special properties which would enable it to find a market in the country at an economic price. The reputation for natural durability which the timber bears in British Honduras was not confirmed by the Laboratory tests, for it was readily attacked by five of the wood-destroying fungi which are common in this country. It is possible that the " graveyard " tests now in progress will throw further light on the subject, but in view of the results obtained in the Laboratory tests the wood cannot be recommended for use in exposed situations in this country.

Special Investigations

5. Idigbo : *Terminalia ivorensis* A. Chev., from Nigeria

A small scale special investigation of the strength properties of Idigbo, undertaken to determine whether the timber possessed the necessary mechanical properties for motor body construction, was completed early in the year. The result showd that idigbo was not particularly well suited for the purpose in view.

6. Nigerian celtis : *Celtis ? Soyauxii* Engl., from Nigeria

Celtis ? Soyauxii Engl. is particularly prone to develop blue stain and, with the object of determining the relative value of various end treatments for preventing this, five logs were treated in various ways prior to shipment to this country. After examination on arrival the logs were converted and such timber as was suitable was subjected to tests to determine whether, and to what extent, the timber could be used in place of ash. Examination showed that none of the end treatments was really effective in preventing staining, and the test work proved that the timber was not comparable to ash in resilience, although it might be used as a substitute for ash for certain purposes where toughness was not important.

7. Meranti pa'ang : *Shorea bracteolata* Dyer
Melantai : *Shorea macroptera* Dyer
Kempas : *Koompassia malaccensis* Maing.
from Malaya

An investigation of the working qualities of the above-mentioned species was undertaken at the request of the Forest Research Institute, Kepong, to complete the work begun at that Institute. Meranti pa'ang was found to have a considerable dulling effect on the teeth of saws and the edges of cutters; Melantai was worked readily with all machine and hand tools; Kempas was hard to plane and dulled the edges of cutters fairly quickly and could not be regarded as an easy wood to work.

B. *Investigations in Progress at the Beginning of* 1935 *and not yet Completed Major Scale Investigation*

8. Ceylon gurjun : *Dipterocarpus zeylanicus* Thw.

It was anticipated that this investigation would be completed early in 1935. Air-seasoning proved to be a much longer process than had been anticipated, however, so that some small part of the testing of air-seasoned material still remains to be completed. It is confidently expected that the report will be ready for issue by February, 1936.

9. Santa Maria : *Calophyllum brasiliense var. Rekoi* Standl., from British Honduras

As in the previous case, the air-seasoning of Santa Maria has proved a long process. The tests have now been completed, however, and only the compilation of the report remains to be done.

10. British Honduras pitch pine : *Pinus caribaea Mor.*

Major scale tests of the properties of the above timber are now approaching completion, although some work on air-seasoned material is still outstanding. The timber appears to possess some promise, but whether it can be marketed in this country will depend on the price at which it can be landed.

Limited Major Scale Investigation

11. Opepe : *Sarcocephalus Diderrichii* de Wild., from Nigeria

This investigation is now almost complete. Some further tests on air-seasoned material are necessary, however. The timber possesses distinct promise for constructional work and flooring and selected material may find some small outlet for cabinet work. Since the investigation was started, information has come to hand that a floor of this timber is being laid in one of the dining halls at St. Catherine's College, Cambridge. The architect responsible for this work has been in contact with the Laboratory and information and assistance in connection with the work have been given.

Preliminary Investigations

12. Okan : *Cylicodiscus gabunensis* Harms., from Nigeria

Preliminary tests on Okan are now approaching completion. A small area of flooring in the form of strip has been laid in one of the corridors at the Laboratory and is very striking in appearance. It is anticipated that the report will be issued at an early date.

13. Odoko : *Scottellia coriacea* A. Chev., from Nigeria

The investigation of the properties of Odoko is now to all intents and purposes finished but the report has not yet been completed. It is anticipated that it will be ready early in 1936.

14. White Olivier : *Terminalia ? obovata* Steud., from Trinidad

An examination of the herbarium material which accompanied the timber for test, at the Imperial Forestry Institute, Oxford, has thrown some doubt on the identity of the species. Further investigation into the matter is proceeding. The stock which is air-seasoning is not yet thoroughly dry but all tests except those on air-seasoned material have now been completed.

15. Nargusta : *Terminalia* sp., from British Honduras

This species was described in the application as *Terminalia excelsa* Liebm. The herbarium material was examined at the Imperial Forestry Institute and as a result there is some question as to whether the name under which the timber was sent is correct. Further investigations will be necessary in order to determine the correct scientific nomenclature. The stock set on one side for air-seasoning is now practically ready for testing and the investigation should be completed early in 1936.

16. Cramantee : *Guarea excelsa* H.B.K., from British Honduras

Tests on the green material have been completed but the parallel tests on air-seasoned material cannot yet be undertaken as the moisture content still exceeds 12 per cent.

17. Waika Chewstick : *Symphonia globulifera* L.f., from British Honduras

The work of testing this timber has proceeded satisfactorily. It will be possible to undertake tests of air-seasoned material at an early date.

18. Cypress : *Podocarpus guatemalensis* Standl., from British Honduras

This timber closely resembles the Podo from East Africa which was tested in 1934. From the material received, however, it would appear that this species is very inferior in size to those in East Africa. The stock which has been air-seasoned is now ready for testing and it is anticipated that the investigation will be completed at an early date.

19. Timbersweet : from British Honduras

When the application for the investigation of the properties of Timbersweet was submitted the timber was provisionally described as *Phoebe* sp. It was decided from the herbarium material, however, that the identity was not as stated in the application. Further work to determine the correct nomenclature has been undertaken. Tests of the green material have been completed and, as the moisture content of the air-seasoning stock is now only a little above 12 per cent., it will probably be possible to begin the testing of this material in the course of a few weeks.

Special Investigations

20. East African pencil cedar : *Juniperus procera* Hochst., from Kenya.

Further work in investigating the causes of warping in this pencil cedar has been undertaken and is still proceeding. No reliable forecast of the time required to complete the investigation can be made at this stage.

21. Queensland walnut : *Endiandra Palmerstonii* C. T. White.

Considerable difficulties have been met with in the investigation of the working qualities of Queensland walnut, and the work has been interrupted owing to unavoidable causes. It has now been resumed, however, with some prospect of being successfully completed in the near future.

22. Kenya olive : *Olea Hochstetteri* Baker

In April the Colonial Forest Resources Development Department in addition to taking over the responsibility of marketing work in connection with colonial timbers also undertook the arrangement of service trials of such timbers outside the Laboratory. The duty of reporting upon this special investigation on the suitability of Kenya olive for flooring, panelling and decorative work thereupon devolved on that Department.

INVESTIGATIONS BEGUN DURING 1935

The following new investigations have been undertaken in the course of the year under review.

Special Investigations

23. Mvule : *Chlorophora excelsa* Benth. & Hook.f., from Uganda

A special investigation of the strength properties, durability and working qualities of mvule in comparison with those of Burma teak was started in November. Tests of the mechanical properties of the green timber are in progress and other tests will follow as accommodation in the various sections involved permits.

24. Mukusu : *Entandrophragma angolense* C.D.C., from Uganda

In October material for a special investigation of certain of the properties of mukusu arrived at the Laboratory from Uganda. Arrangements have been made for veneering tests to be carried out as this species is closely related to

the Sapele mahogany from West Africa, which is largely used in this country in the form of veneers. The further tests required by the Forest Department of Uganda will begin immediately.

25. Mufumbi : *Entandrophragma utile* Sprague, from Uganda

The test material arrived at the same time as the mukusu and will be submitted to the same type of investigation. It was at one time believed that this was the species exported from West Africa as Sapele mahogany but more recent investigations have shown that most of the wood which reaches Europe under that name is *Entandrophragma cylindricum*. A preliminary investigation of the properties of the latter to determine whether it was suitable for the manufacture of air screws was carried out at the Laboratory in 1931.

26. Keruing : *Dipterocarpus Baudii* Korth.
Kumus : *Shorea laevis* Ridl.
Merbau : *Intsia Bakeri* Prain.
Memesu : *Shorea pauciflora* King.
Tempenis : *Sloetia sideroxylon* Teysm. & Binn.
all from Malaya

Material for tests of the working qualities of the above five species on behalf of the Malay Forest Research Institute arrived at the Laboratory at the end of May. The material was stacked to air-season and when the process has been completed tests will be undertaken.

For some time after the work on Empire timbers was begun it was the custom to issue reports on tests of green and kiln-seasoned material and thus obviate the delay which must necessarily have ensued due to the relatively long time required for air-seasoning. In every case, however, material was stacked for air-seasoning and tests of the air-seasoned material were subsequently carried out. In the course of the year reports on tests of air-dried material of the following species have been prepared and issued as addenda to the reports on the green and kiln-seasoned material :

Abura : *Mitragyna stipulosa* Kuntze
Keruing : *Dipterocarpus cornutus* Dyer
Meranti tembaga : *Shorea leprosula* Miq.
Turpentine : *Syncarpia laurifolia* Tenore
Coachwood : *Ceratopetalum apetalum* D. Don.
Purpleheart : *Peltogyne ?pubescens* Benth.
African walnut : *Lovoa Klaineana* Pierre ex Sprague

A confirmatory test of the natural durability of *Mansonia altissima* A. Chev. has also been completed and it is satisfactory to note that this timber has proved very durable under laboratory tests.

Practical Trials of Empire Timbers at the Laboratory

The following Empire timbers have been subjected to new or extended practical trials in some form or other during the year :

Banak : *Virola merendonis* Pittier
Kenya camphor : *Ocotea usambarensis* Engl.
Ceylon gurjun : *Dipterocarpus zeylanicus* Thw.
Munyama : *Khaya anthotheca* C.DC.
Odoko : *Scottellia coriacea* A. Chev.
Okan : *Cylicodiscus gabunensis* Harms.
Opepe : *Sarcocephalus Diderrichii* De Wild
Santa Maria : *Calophyllum brasiliense* var. *Rekoi* Standl.
Yemeri : *Vochysia hondurensis* Sprague.

APPENDIX IIA

STANDING CONFERENCE ON TIMBER UTILIZATION

CONSTITUTION

Chairman :

Sir JOHN M. STIRLING MAXWELL, Bart., K.T.

Members appointed to represent Dominions, India, Colonies, and other units of Empire

Representing :	*Members :*
Australia	F. L. McDOUGALL, Esq., C.M.G.
New Zealand	N. L. WRIGHT, Esq. F. H. TAYLOR, Esq.
South Africa	F. J. DU TOIT, Esq.
India	Sir HUGH WATSON.
Newfoundland	Rt. Hon. Sir FRANCIS DYKE ACLAND, Bart., M.P.

Members appointed by the Department

Nominated by :	
Colonial Office	R. V. VERNON, Esq., C.B. Major R. D. FURSE, D.S.O. Major F. M. OLIPHANT. Major J. R. COSGROVE, D.S.O., M.C.
Imperial Forestry Institute.	Professor R. S. TROUP, C.M.G., C.I.E., D.Sc., F.R.S.
Ministry of Agriculture & Fisheries, Royal Botanic Gardens, Kew.	Sir ARTHUR W. HILL, K.C.M.G., Sc.D., F.R.S.
Imperial Institute ..	J. P. FRASER, Esq. S. E. CHANDLER, Esq., D.Sc.
Timber Development Association.	E. H. B. BOULTON, Esq.
Department of Scientific and Industrial Research.	W. A. ROBERTSON, Esq. Director of Forest Products Research. W. E. McKEE, Esq.

APPENDIX IIB

RULES AND STANDING ORDERS OF THE CONFERENCE ON TIMBER UTILIZATION

(*Revised 10th September,* 1935.)

1. *Objects*

The Department of Scientific and Industrial Research having agreed to hold available, for the assistance of the various parts of the Empire overseas, under financial arrangements to be approved from time to time by the Department, the facilities of its Forest Products Research Laboratory at Princes Risborough for the investigation of the qualities of particular timbers

(which determine their uses) and for furnishing technical information of importance in marketing such timbers, it has been decided to establish a standing conference to act as a consultative and advisory body to the Department and to the various units of the Empire overseas which desire to make use of these facilities, or to be represented on the Conference.

2. *Constitution*

Any Dominion, Colony, or other unit of the Empire overseas which makes use of these facilities or expresses a wish to be represented on the Conference will be entitled to appoint one or more representatives to membership of the Conference. The names of all representatives so appointed will be communicated to the Department by the Office of the appointing unit of Empire. The Department will appoint representatives to be members of the Conference who may include persons nominated by other Departments of State in the United Kingdom interested in the use of Empire-grown timbers, a person or persons nominated by the Minister of Agriculture and Fisheries as representing the Royal Botanic Gardens at Kew, persons nominated by the Governing Bodies of the Imperial Institute and the Imperial Forestry Institute, persons nominated by any timber trade organisation in the United Kingdom on an invitation issued on the recommendation of the Standing Conference, and persons not included in the foregoing categories who have in the past been of conspicuous service, as members of the Empire Timbers Committee or otherwise, in promoting the use of Empire-grown timbers in the United Kingdom.

3. *The Year*

For the purpose of these rules and standing orders the year is understood to run from 1st January to 31st December.

4. *Chairman*

The Chairman will be appointed by the Department from among the members of the Conference as defined by its constitution as set out in 2 above. He will hold office for three years, and will be eligible for reappointment for a further period, not exceeding three years, on the completion of a term of office.

5. *Secretarial work and place of meeting*

The Department will undertake the secretarial work of the Conference and will provide a place for its meetings.

6. *Meetings*

Two ordinary meetings of the Conference will be held in each year. A notice of the date, time and place of each ordinary meeting will be sent to each member one month before the meeting. A special meeting may be called at any time by the Chairman in his discretion and shall be called by the Chairman on the requisition of the representative or, if more than one, the representatives of any unit of the Empire appointing to membership of Conference, such requisition to be accompanied by notice of the question or questions to be raised at the meeting. At least one week's notice of the date, time and place of each special meeting will be sent to each member.

7. *Business*

The regulation of the business of the meetings of the Conference will be in the hands of the Chairman. A member wishing to bring any matter before a meeting of the Conference is requested to give notice to the Director, Forest Products Research Laboratory, Princes Risborough, Bucks., fourteen days before the meeting, so that the matter may be included as an item on the agenda. Matters to be so brought before the Conference would include

those which bear on the marketing of any timber grown in the part of the Empire overseas which the member may represent. An agenda paper for each meeting will be circulated so as to reach members at least three days before the meting.

8. *Presentation of reports to the Conference*

A brief progress report on the work carried out by the Department on Empire-grown timbers under the arrangements defined in 1 above during the period since the last ordinary meeting of the Conference will be presented to the Conference at each ordinary meeting by the Department. Members representing various units of the Empire overseas or the institutions or trade organisations defined in 2 above are invited to present similarly to the Conference progress reports on any work carried out by the unit of Empire, institution or organisation they represent which appears to be of general interest in promoting the objects of the Conference. Such reports should reach the Director, Forest Products Research Laboratory, at least fourteen days before the meeting at which they are to be presented.

9. *Reports of the proceedings of the Conference*

As soon as possible after 31st December in each year, the Conference will present to the bodies appointing members a report of its proceedings during the past year. These reports may be printed and published by the Department in its discretion.

APPENDIX III PUBLICATIONS

(A complete list to-date of the Laboratory's publications may be obtained on application to the Director, Forest Products Research Laboratory, Princes Risborough, Aylesbury, Bucks.)

I.—LIST OF PUBLICATIONS ISSUED DURING 1935

A.—*Stationery Office Publications**

	Price s.	d.
Report of the Forest Products Research Board for the year 1934 ..	1	6
RECORDS :—		
No. 1.—The Testing of Timbers at the Forest Products Research Laboratory .. .. (1935)	0	6
No. 2.—Strength Tests of Structural Timbers. Part I. General Principles, with Data on Redwood from Gefle and Archangel. By C. J. Chaplin, M.Sc., M.E.I.C., M.I.Mech.E., and J. Latham, B.Sc. .. .. (1935)	0	6
No. 3.—Experiments on the Preservation of Mine Timber. Progress Report No. I. By J. Bryan, M.Eng., Assoc.M.Inst.C.E., and N. A. Richardson B.Sc., A.I.C. (1935)	0	6
No. 4.—Timber Seasoning. By R. G. Bateson, B.A. .. (1935)	0	6
No. 5.—The Moisture Content of Timber in new Buildings. By R. A. G. Knight, B.Sc.(Eng.), A.M.I.Mech.E. (1935)	0	6
LEAFLETS :—		
No. 3.—*Lyctus* Beetles and their Control (*Revised edition*) (1935)		
No. 7.—Moisture Content Determination by the Oven-drying Method .. .. .. (*Revised edition*) (1935)		
No. 8.—The Common Furniture Beetle (*Revised edition*) (1935)		
No. 9.—The Moisture Content of Timber in Use .. .. (1935)		
No. 10.—Timber Drying Kilns. The Overhead Internal Fan Kiln .. .. (1935)		

These leaflets are gratis and may be obtained only from The Director, Forest Products Research Laboratory.

B.—*Other Publications*†

ARMSTRONG, F. H.

Further Tests on the Effect of Progressive Decay by *Trametes Serialis* Fr. on the Mechanical Strength of the Wood of the Sitka Spruce. *Forestry*, 1935, **9**, 62–64.

BARKAS, W. W.

The Fibre Saturation Point of Wood. *Nature*, 1935, **135**, 545.

* *Obtainable from any of the Sale Offices of His Majesty's Stationery Office, LONDON : Adastral House, Kingsway, W.C.2 ; EDINBURGH*, 120, *George Street ; MANCHESTER :* 26, *York Street ; CARDIFF :* 1, *St. Andrew's Crescent ; BELFAST :* 80, *Chichester Street.*

† *Reprints of papers not marked with an asterisk are obtainable at a nominal cost from the Director, Forest Products Research Laboratory.*

Bateson, R. G.

Why kiln-drying Furniture Wood reduces Costs and Returns. (The Correct Method of Seasoning Timbers.) *Furniture Mfr.*, 1935, **5,** 8–9.

Kiln-Drying will stop Splitting and Warping. *Furniture Mfr.*, 1935, **5,** 42–43.

Campbell, W. G.

The Chemical Aspect of Timber Research. *J. Soc. Chem. Ind., Lond.*, 1935, **54,** 302; also in *Proc. Chem. Engng. Gr. Soc. chem. Ind.*, 1934, **16,** 116–125.

The Starch and Related Polysaccharides of certain Hardwoods. I. The Preparation and Properties of Oak and Walnut Starch. *Biochem. J.*, 1935, **29,** 1068–1080.

Wood Hemicelluloses. *Nature*, 1935, **136,** 299.

A Note on the Inorganic Infiltration Theory of Wood Decay. *J. Soc. chem. Ind., Lond.*, 1935, **54,** 372T–374T.

Campbell, W. G., and Long, S. H.

The Composition and Origin of a Calcareous Deposit found in the Wood of *Millettia pendula* Benth. *Emp. For. J.*, 1935, **14,** 250–252.

Campbell, W. G., Taylor, K. F., and Bryant, S. A.

Some Observations on the Action of certain Calcium Salts on Wood with special Reference to the "Inorganic Infiltration" Theory. *J. Soc. chem. Ind., Lond.*, 1935, **54,** 103T.

Campbell, W. G. and Wiertelak, J.

The Chemistry of the White Rots of Wood. IV. The Effect on Wood Substance of *Ustulina vulgaris* Tul. *Biochem. J.*, 1935, **29,** 1318–1321.

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*A Survey of Insect Damage to Indian Timbers. *Indian For.*, 1935, **61,** 163.

Cartwright, K. St. G., and Fisher, R. C.

Decay of Timber in Houses. Part I. Fungi injurious to Timber. Part II. Insects injurious to Timber. *Trans. chart. Surv. Instn.*, 1935, **67,** 184–250.

Chaplin, C. J.

Forest Products Research: Objectives and Methods. *Brit. Emp. For. Conf.*, 1935.

Clarke, S. H.

Application of Microchemical Tests in assessing the Quality of Ash Timber. *Nature*, 1935, **135,** 910.

Recent Work on the Relation between Anatomical Structure and Mechanical Strength in English Ash (*Fraxinus excelsior*). *Forestry*, 1935, **9,** 132–138.

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Empire Timbers—Trade in 1934. *Timb. Plywood*, 1935, **68,** 208.

*Empire Timbers for Furniture. *Furniture Rec. Furnisher*, 1935, **103,** 104–105.

*The Growth of a Tree. *Timb. News Sawm. Chron.*, 1935, No. 2014, 186–187; Part II. *Loc. cit.* No. 2015, 233–234; Part III. *Loc. cit.* No. 2016, 276 and 279.

The Use of Willow for Cricket Bats. *Emp. For. J.* 1935, **14,** 233–234.

FISHER, R. C.

Duration of Life-cycle of the Death Watch Beetle. *Nature*, 1935, **135,** 102.

*The Need for Forest Entomologists, with special Reference to the Pin-hole Borer Problem. Paper read before the *Fourth Imperial Entomological Conference*, 1935.

HARRIS, P.

Recent Woodworking Studies. What Experiments at the Forest Products Research Laboratory have revealed. *Timb. Tr. J.*, Special Issue, June 26th, 1935, 229–230.

Correct Cutting Angles mean Perfect Finish. *Furniture Mfr.*, 1935, **4,** 209–210.

*Observations concerning Circular Saws. *Timb. News Sawm. Chron.*, 1935, No. 2019, 426.

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*The Grading of Timber. Part I. *Timb. News Sawm. Chron.*, 1935, No. 2017, 322–324; Part II. *Loc. Cit.*, No. 2019, 410–412.

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*The Behaviour of Timber in Use. *Timb. News Sawm. Chron.*, 1935, No. 2020, 450–452.

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The Humidity-Moisture Content Relations of Wood. *Engineering*, 1935, **139,** 472–473.

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*The House Longhorn Beetle. A New Pest of Softwood Structural Timbers. *J.R.Inst. Brit. Archit.*, 1935, **42,** 1148.

*Recent Work on the Food Relations of the Lyctus Powder-post Beetles. Paper read before the *British Association*, 1935.

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Timber Research at Princes Risborough, a Bird's-eye View. *J. Inst. Brit. Carr. Mfrs.*, 1935, **24,** 8–20.

STEVENS, W. C.

Wood Bending. *Timber Tr. J.*, 1935, **132,** xxi.

The Effect of Pin-knots on the Bending of Timber, illustrated from Sweet Chestnut. *Forestry*, 1935, **9,** 139.

STILLWELL, S. T. C.

*Forest Products Research. *Ill. Carp. Build.*, 1935, **116,** 54.

The Seasoning of Timber. Is Long Air-seasoning Essential? *J. R. Inst. Brit. Archit.*, 1935, **42,** 381.

*Air- or Kiln-seasoning. *Timb. News Sawm. Chron.*, 1935, No. 2018, 384–385.

REST, E. D. VAN.

Statistical Methods for Timber Research. *Brit. Emp. For. Conf.*, 1935.

Utilisation of Small Material. *Brit. Emp. For. Conf.*, 1935.

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No. 5.—Empire Timbers from Home and Overseas for Building and Structural Purposes. By Major J. R. Cosgrove, D.S.O., M.C., M.E.I.C. .. .. (1932) 1 3

No. 6.—Dry Rot in Buildings. Recognition, Prevention and Cure (*Revised edition*) (1933)

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